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A NEW CONSORTIUM

IT WAS THE SERGEANT-MAJOR WHO, WHEN ASKED in the court-martial for his definition of dumb insolence, said that he could not give one, but he knew it when he saw it. Much the same comment might be passed about 'automation', a catchword new in itself, but representing a concept with origins almost as venerable as those of the behaviour which the sergeant-major failed to define, and, because usually we know it when we see it, a convenient tag to describe what is often an involved matter.

Most electrical engineers, if asked to distinguish between mechanization and automation, would use the presence or absence of feedback as the most useful discriminatory test. If then we hold automation to be that form of mechanization which comprises a control element acting on a closed-loop pattern, we cannot say that this concept is very new. But what are new are the extraordinary strides that have been made in the applications of automation, resulting from the development and near-perfection of the computer, and in particular, the digital-computer. A review of persons likely to have an interest in automation and computation reveals a breath-taking size of field. But the interests comprised seem to fall naturally into three broad groups. First there are those who are interested in the engineering applications of automation; for example the advanced transfer-machine techniques sometimes referred to as Detroit automation, and the control of machine tools by programmes frequently determined by associated digital computers. Secondly, there are those whose interests centre on the design, construction and use of the computers themselves. In this group alone the field is wide, ranging from the mathematician concerned with logical design and programming techniques, to the electrical engineer concerned with the ultimate refinements of the computer circuit-elements themselves. Thirdly, and certainly no less important than either of the foregoing, are all those bodies concerned with the human element in its relation to the introduction of automation and to economic questions generally. Though all these techniques and their applications are so new, the pace of their introduction is accelerating rapidly. But at present the record of automation and computation developments is spread most diffusely over a very wide range of literature. Nor is it easy to be certain what papers and discussions may be coming forward in the programmes of the various bodies who give attention to these matters from time to time.

Since the Convention on Digital Computer Techniques held by The Institution in April last year, it has become even more clear that some scheme of co-ordination was most desirable in the national interest, in order to meet two pressing needs. First to provide a clearing house, so that information concerning the activities of the various interested bodies could be interchanged and made available to all their members; secondly, to afford a means of obtaining a proper coverage of British activities to enable the most effective presentation of the British case to be made in international conventions and the like.

The British Conference on Automation and Computation, now in process of being set up, will, it is confidently hoped, provide a practical, convenient and economical answer to these two needs. Details of the proposed structure, with its three Groups dealing respectively with engineering applications (Convener, The Institution of Mechanical Engineers); the development and applications of computers, etc. (Convener, The Institution of Electrical Engineers) and the sociological and economic aspects (Convener, The British Institute of Management), were announced in the *Journal* last month. The announcement contained a reference to a further essential feature of the scheme: the setting up of a central liaison General Committee, which will facilitate the interworking of the three substantially autonomous Groups, and generally act as a point of contact for all external inquiries. It will also carry out such central functions as may be delegated to it by the Groups: in particular, no doubt, the preparation of a regular bulletin giving details of the activities, concerning automation and computation, of all the various bodies associated with the Groups. The formative discussions are continuing and a further announcement will be made as soon as the Conference has taken its final shape.

The History of Electrical Engineering

7. THE DEVELOPMENT OF THE ELECTRICAL LOAD

In previous articles the author has described the early work on magneto-electric generators and the use of the arc lamp in lighthouses. After briefly recapitulating this work he shows how the further development of electric generators depended on the growth of demand, and how this in turn depended on the invention of new and more convenient light sources. Among the pioneers at this stage of electrical history are Sir Joseph Swan and Thomas Edison, whose rivalry stimulated the development of the incandescent lamp.

C. MACKECHNIE JARVIS, MEMBER

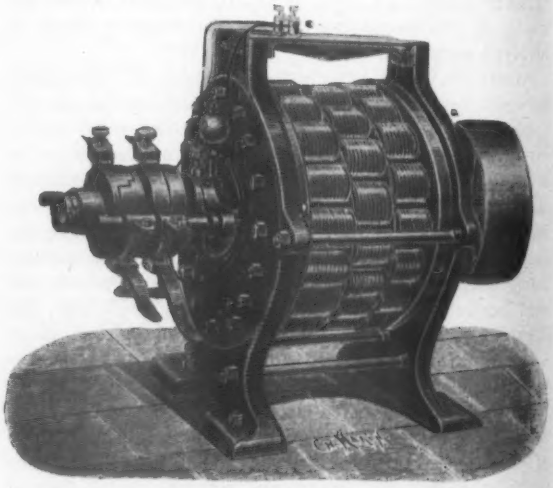
It is paradoxical that uses for electrical power had been established years before satisfactory generating plant became available.

In earlier articles in this series, reference has been made to successive attempts to employ the carbon arc for lighthouse and general illumination. The initial experiments by Staite and Petrie (*circa* 1846) failed because the primary cells from which the lamps were supplied were too costly in upkeep. Although the subsequent work by Holmes on behalf of the Corporation of Trinity House from 1856 onwards proved successful, it became obvious that the magneto-electric machines then in use were much too bulky in relation to their output (and hence much too costly) for general application.

The development of the dynamo-electric machine has also been discussed and credit for producing the first practical continuous (i.e. non-pulsating) current dynamo shown to belong to Zénobie Théophile Gramme (1826–1901), the first of whose machines, with the well-known ring armature and multi-segment commutator, was exhibited in Paris in July 1871. In the ensuing decade Gramme machines were made under licence in several countries and competitors entered the field (lawsuits brought by the Gramme interests notwithstanding).

No pioneer manufacturer can achieve success unless he has an assured market and a more or less reliable product. None would deny to the Gramme organization soundness of design and general reliability, subject only to a limitation imposed by commutation, and by 1870 dynamos were in demand. It was known to Gramme and his contemporaries that arc lighting in lighthouses was supplied from permanent-magnet alternators of the Holmes and Alliance types, which were very bulky and expensive. Dr. Wilde in 1863 patented a single-phase alternator, embodying a separate permanent-magnet exciter* mounted above it, but his machine, which was fitted with H-type armatures, gave considerable trouble because of the heating of the solid cores by eddy currents.

Wilde's later machines, dating from about 1867, were the first alternators which did not depend upon excitation from permanent magnets. A shuttle armature was used which carried two windings, namely a main winding which supplied power to the external circuit via slip rings and an auxiliary winding connected to a two-part commutator for the purpose of exciting the field windings. Heating in the solid cores in these machines was accentuated by the pulsating nature of the excitation current and gave rise to such overheating that the machines could not be run for more than a few hours continuously!



1 *Wilde's stationary-field disc alternator, 1878*

This machine, which was self-excited, closely resembled a separately excited alternator patented by Wilde in 1867.

The introduction of the Jablochkoff electric candle in 1876, to which further reference will be made, created a market for single-phase alternators, and in 1878 both Gramme and Wilde produced new machines of this type.

The Gramme alternator was of the rotating-field

* An illustration of an early Wilde machine appeared in Fig. 5 of Part 4 of this history (*Journal*, September 1955, p. 566). Unfortunately, the illustration and caption do not agree. It was intended to illustrate the well-known combination of a generator with electromagnetic field system, surmounted by a permanent magnet exciter, made in 1863. The figure reproduced is that of a generator of this period on which the exciter has been replaced by a self-excited dynamo, and which dates from 1867. The author has been unable to trace the existence of an example of the original combination with permanent magnet exciter, and if any reader knows of the whereabouts of such a machine, the information will be welcomed.

pattern with ring winding and was excited from a bi-polar dynamo, also with a ring-type armature built into the same carcase.

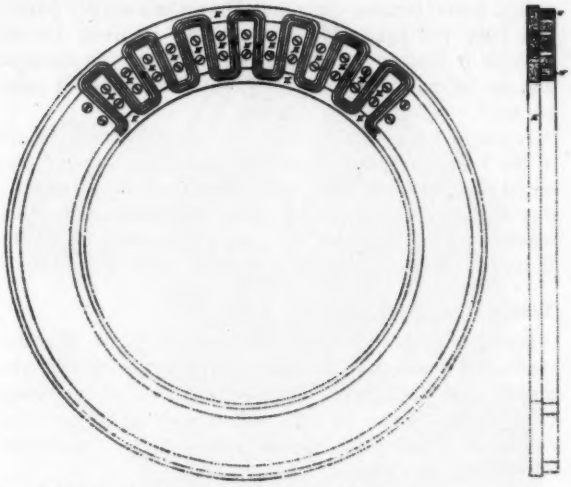
Wilde adopted a multiple-coil disc rotor in the tradition of F. H. Holmes, and the arrangement of his alternator is illustrated in Fig. 1.

Either one or two of the coils on the rotor are connected to the field system, via the two-part commutator shown, the remaining bobbins feeding the slip rings in the usual way. Other manufacturers also made use of disc rotors, which continued in popularity for some years. A Siemens alternator of 1878 with a separate exciter is illustrated in Fig. 2. In this machine, the iron cores, which Wilde used, were omitted from the centres of the rotating bobbins, thus producing the first of the 'copper' alternators.

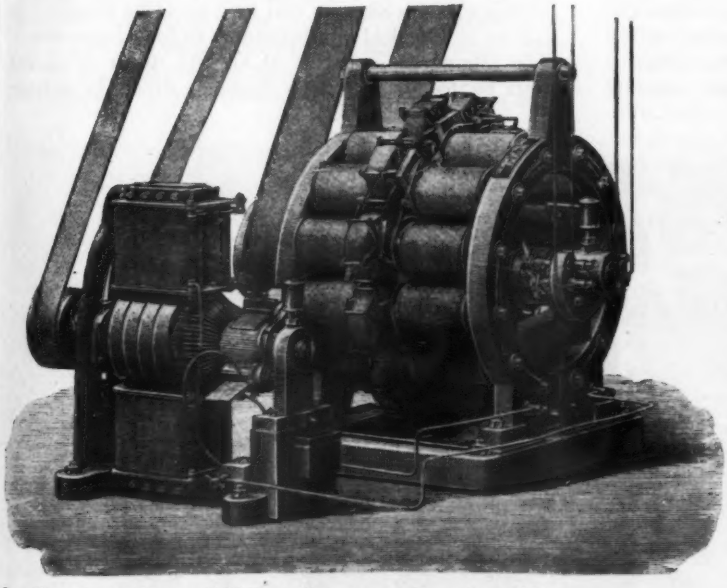
Kelvin takes a Hand

At this period, Lord Kelvin, F.R.S. (1824–1907), then Professor Sir William Thomson, was interested in the construction of generators and patented several improvements including a special form of construction for the disc alternator which he described in his patent specification No. 5668 of 1881 as a 'zig-zag' winding, Fig. 3. He does not appear to have developed this commercially, but shortly afterwards S. Z. de Ferranti, F.R.S. (1864–1930), at that period a very young man, obtained in association with Alfred Thompson a patent (No. 3419 of 1882) for an 'ironless' alternator disc with a radial winding, also described as 'zig-zag', and he followed this by patent No. 3702 of 1883 in which the now well-known disc alternator is completely described. Dr. Ferranti, who later became President of this Institution for the years 1910 and 1911, was for a short time employed by the Siemens organization in England, but on the advice of friends he left in 1882 at the age of eighteen to found his first company, Messrs. Ferranti, Thompson and Ince, his partners being Mr. Alfred Thompson, an electrical engineer, and Mr. Francis Ince, a solicitor. The company was formed for the purpose of manufacturing electrical equipment, particularly the disc alternator, on the rotor of which was employed a continuous winding of insulated copper ribbon, as illustrated in Fig. 4. The prototype of this machine was made by Ferranti in the summer of 1881. Apart from its disc, the Ferranti 'copper' alternator bore superficial resemblance to Dr. Wilde's machine of 1878.

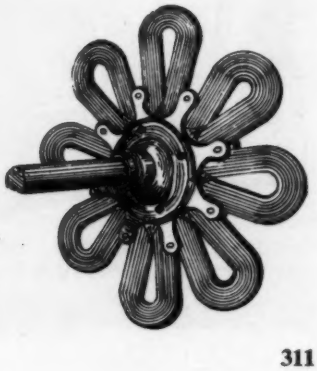
The work of Sir William Thomson in the same field was brought to Ferranti's



3 *Kelvin's zig-zag winding for disc alternator*
Taken from the patent specification of 1881.



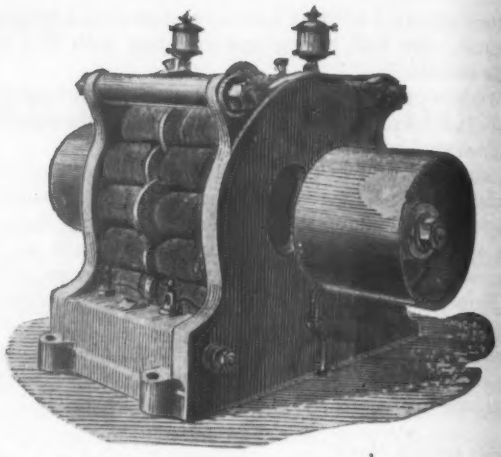
2 *Siemens stationary-field disc alternator with exciter, 1878*



4 *Ferranti's zig-zag rotor*

notice, and it became clear that Thomson's earlier patent had been infringed. The matter was resolved by an agreement whereby in return for a royalty the machine was to be manufactured by Ferranti under their joint names.

It should here be mentioned that one important feature of the Ferranti construction was that the rotor windings could expand freely in a radial direction, thus avoiding one of the more serious difficulties associated with other machines of this period. The general appearance of the Ferranti–Thomson alternator may be judged from Fig. 5.

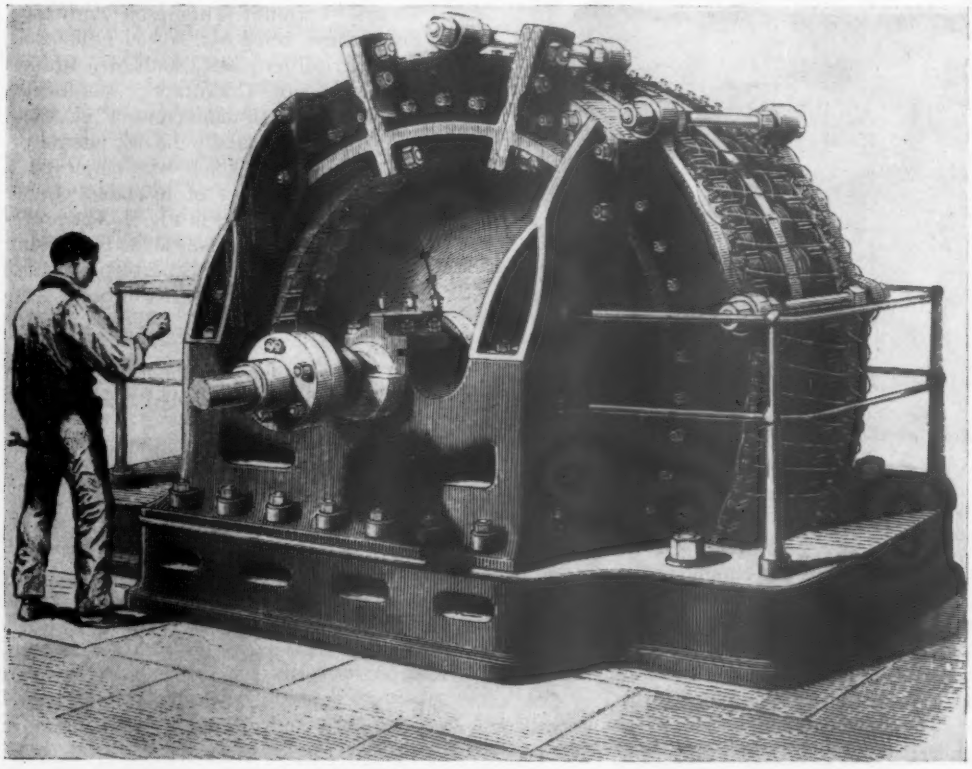


5 *Ferranti–Thomson alternator*

Some Large Alternators

Another pioneer of this period was J. E. H. Gordon (1852–1893), sometime manager of the electric light department of the Telegraph Construction and Maintenance Co. About the end of 1882, Gordon designed and had constructed under his supervision some of the largest alternators then known.

These machines had a maximum output of 115 kW at 105 volts and weighed 18 tons each. They were directly coupled to Rennie compound steam engines, operating at 160 lb/inch^2, and ran at a speed of 146 r.p.m. Three such alternators of the rotating-field type, shown in Fig. 6, each measuring approximately 10 ft in diameter, were built for the Paddington terminal station of the Great Western Railway. The stator windings (Fig. 7) were duplicated and constituted two entirely separate single-phase circuits. Each distinct phase on the stator consisted of fourteen groups of coils operating in parallel, connected individually to the switchboard, where the arrangements were such that they could be brought into service or switched out, according to load requirements. The alternators operated at slightly under 40 c/s and were excited by Crompton dynamos driven by separate



6 *Gordon's rotating-field alternator*

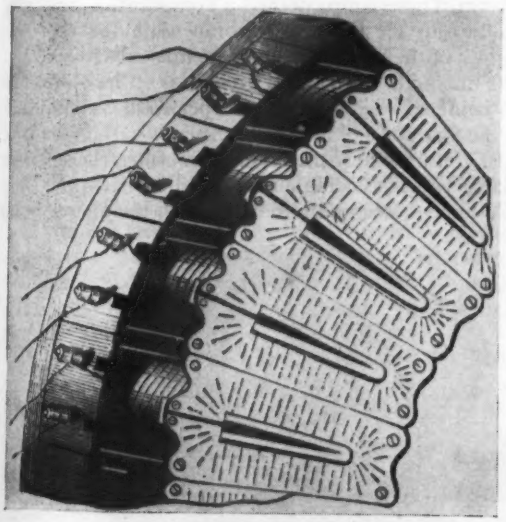
This machine was installed at Paddington station in 1885.

steam engines. The plant supplied a mixed lighting load, consisting of approximately 4100 Swan incandescent lamps of 25 candle-power, equivalent to some 340 kW, and up to 100 arc lamps, requiring between 50 and 100 kW, amounting in all to a connected load of 440 kW.

These generators, which were unusually large for this period, should not be taken as typical of prevailing practice. Nor is it to be expected that they operated without trouble; in spite of elaborate precautions taken during manufacture, serious overheating of the stator windings was encountered, and it was found necessary to rebuild, using laminated cores. In judging the work of the pioneer designers it must constantly be remembered that practice was years in advance of theory and much that is obvious to-day had to be learned by operating experience, often at great cost.

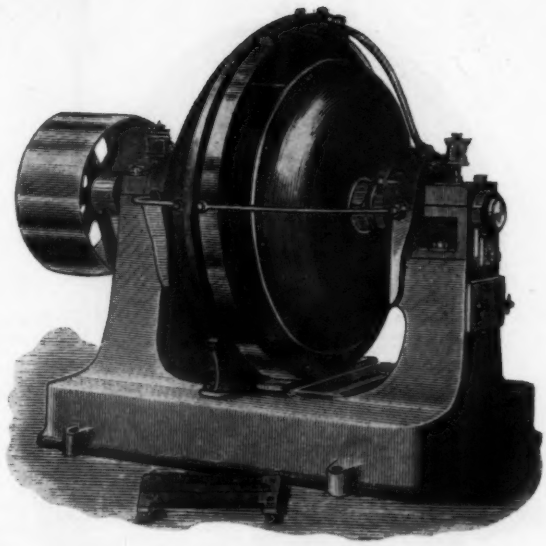
On the Continent, large alternators were constructed by the firm of Ganz of Budapest to the design of Zipernowsky and were exhibited at the Vienna Exhibition of 1883. The output was probably comparable with that of the Gordon machine.

Another pioneer well remembered in this Institution, of which he became President in 1908, was W. M. Mordey (1856–1938), to whom is due the unique machine sometimes referred to as the Mordey–Victoria alternator, Fig. 8. This was manufactured to his design around 1886 by the Anglo-American Brush Corporation. The construction will be clear from Figs. 9 and 10; a single field



7 *Detail of the stator of the Gordon alternator*

coil clamped between two heavy steel pole pieces rotated; the pole pieces were spaced apart and the machine was so assembled that each pole piece was positioned on the opposite side of the stator assembly. The stator windings consisted of individual coils of copper ribbon wound on porcelain formers, without iron cores. The field was



8 *Mordey rotating-field alternator, circa 1886*

excited from a separate dynamo of Mordey design to which the type name Victoria had previously been given.

The output from the 'alternator' consisted of unidirectional pulses of good waveform, and it is stated that the flywheel action of the field magnet was most effective in smoothing out the cyclic irregularity of the reciprocating steam engines of the period. In common with the Ferranti machine, the Mordey alternator could be manufactured for high-voltage working without difficulty, and, for series arc-lamp circuits, outputs of 34 to 40 kVA at 2000 volts were not unusual. Unlike the Ferranti machine, however, the stator coils were carried from an external ring and hence could not expand freely outwards. Under conditions of heavy load the heat generated in the machine was considerable, and according to Mr. Kilburn Scott* it was not unusual for the coils to distort sideways and so foul the rotor, which had an air-gap clearance of 5 mm on each side.

The principal use for electrical generators at this period was for the purpose of illumination, although it should be added that the firm of Wilde and Co. were supplying a considerable number of dynamos for the electroplating industry. Before considering further developments in the generation and distribution of energy it is necessary to review contemporary developments in the field of electric lighting.

The Arc Lamp Improved

The early history of the development of the electric arc lamp by Staite and Petrie in the years 1847–1850, and the unsuccessful attempts of these pioneers to introduce a system of electrical illumination fed from primary

* Mr. Kilburn Scott was an early pioneer of electricity supply. His remarks were made in a discussion of a paper 'Electrical Invention and Re-invention', *Transactions of the Newcomen Society*, 1940, 20, p. 87.

9 *High-voltage stator of Mordey alternator*

batteries, has been described in an earlier article in this series (March 1955).

Arc lighting was successfully revived in England by F. H. Holmes around 1856 for lighthouse illumination, and these developments have been followed in a further article (May 1955). The generators used by Holmes were of the magneto-electric type; large and heavy for their output, they were unsuitable for general application.

After the death of Staite in 1854, initiative in the development of arc lamps passed to France. It is true that F. H. Holmes developed a lamp, which was adopted by Trinity House, but the number of English lighthouses converted to electricity around the 1860s was relatively few, in contrast with the activities of the French lighthouse authority, Administration des Phares.

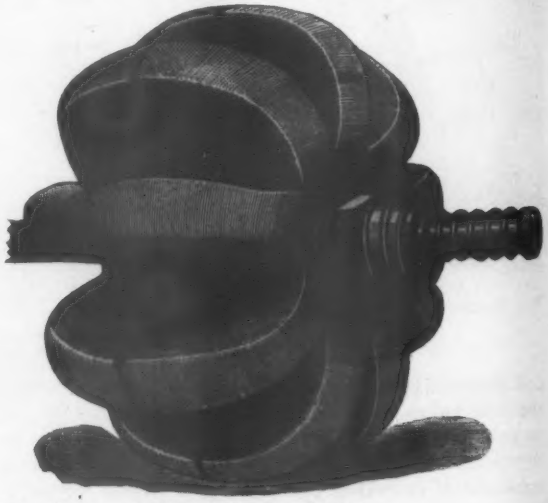
In France, J. B. L. Foucault, V. L. M. Serrin and J. Duboscq were pioneers in this field, and of the three Serrin alone maintained his interest in the subject from the time of his first patent in 1857, until with gratification he saw his lamps come into general use some fourteen years later, when the introduction of the Gramme dynamo in 1870–71 virtually established the availability of electric power. Lamps designed by Serrin and Duboscq are shown in Figs. 11 and 12. Thus, for some years, France led the world in arc lighting. Most appropriately, Serrin lamps were installed in 1873 in the Paris factory of Breguet, where the Gramme dynamos were made, and from this time onwards public interest in arc lighting was reawakened. The first sales of complete lighting installations were to private concerns, and pride of place goes to the mill of Heilmann, Ducommun and Steinlein at Mühlhausen, in which four Gramme dynamos and four Serrin arc lamps were working in August 1875. Similar installations in the Menier chocolate factory at Noisiel, and the Menier rubber works at Grenelle were completed in the same year. Further notable French installations were those at La Chappelle station of the Compagnie du Nord (1876) and the Lyons station of the P.L.M. Company, where a twelve-lamp installation, supplied from one generator, was working in 1877. The latter represented a great advance, because hitherto it had been thought necessary to provide a separate generator for each arc lamp.

In England the new light came slowly in spite of the fact that the electrical Press of those days had repeatedly drawn attention to the developments in electrical illumination which were taking place in France.

Two reasons can be advanced to explain this state of affairs. The more probable explanation is that both dynamos and arc lamps at this period would have been dependent upon Continental sources of supply, but recollection of the heavy financial losses resulting from the attempts of an earlier generation of English pioneers to provide electrical illumination from arc lamps fed by Daniell cells could also have been a retarding factor.

In the late summer of 1878 the situation changed abruptly, when a number of lighting schemes were announced. By the end of August the exterior of the Gaiety Theatre in London was lit by six Lontin arc lamps, and about the same time, Col. R. E. B. Crompton imported Gramme dynamos and arc lamps, which he installed in the new pipe foundry of the Stanton Ironworks in Derbyshire, of which he was then a director. The arc lamps so far discussed have been of the type requiring a relatively heavy current of 20 amp at 50 volts per lamp. These lamps needed a complicated regulating or follow-up mechanism to compensate for the consumption of the electrodes and were thus relatively costly.

The luminous efficiency of arc lamps at the outset was high, being some 8 to 12 lumens per watt, as compared with the figure of 1·5 to 1·6 for the early carbon filament lamps. Unfortunately the luminous output from a single arc lamp was considerable and varied between 8 500 and 13 000 lumens, according to the design, the figures being

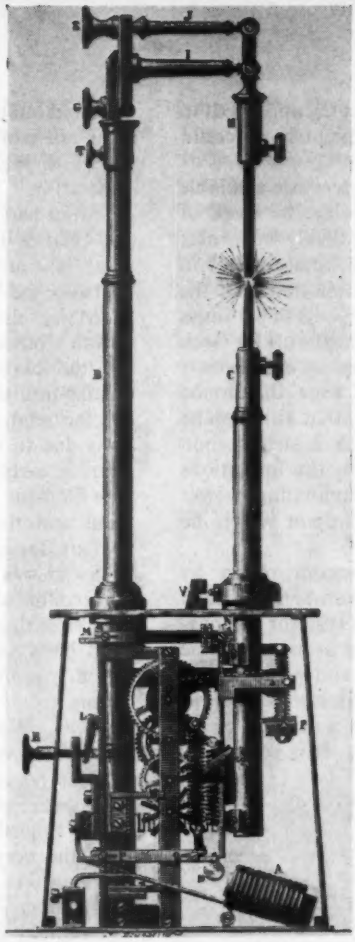


10 *Rotor assembly of Mordey alternator*

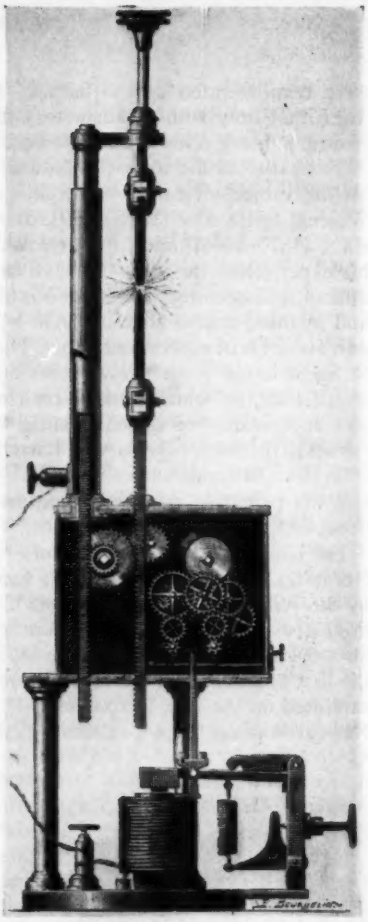
approximations derived from contemporary data. Judged by prevailing standards of illumination, this was considered very much too high for offices and domestic premises and the 'sub-division of the electric light' thus became both the goal of inventors, and, as will be seen later, a subject of controversy between scientists of repute.

The Electric Candle and the First Street Lighting

In 1876 lighting by electric arc lamps was revolutionized by the invention of the 'electric candle' by Paul Jablochkoff (1847–1894), a former telegraph officer in the Russian army who resigned his commission with a view to emigrating to America. It is said that he found Paris so receptive of his ideas, that he abandoned his original intention and obtained sufficient financial backing to start manufacture in France. The famous 'candle' lamp, illustrated in Fig. 13, consisted of two parallel carbons, usually 4 mm in diameter, mounted vertically, separated by a strip of china clay and bridged at the upper end by a cap of graphite. When the lamp was energized the graphite was consumed, resulting in the formation of an arc between the two pencil electrodes which burned downwards at a slow rate. The success of the Jablochkoff lamp, which required 8–9 amp only, was immediate, and early in the following year the first large installation consisting of 80 lamps was completed at the Grands Magasins du Louvre in Paris.



11 *Automatic feed mechanism of Serrin's improved arc lamp, 1859*



12 *Feed mechanism of Duboscq arc lamp, 1858*

The Jablochkoff lamp reached England in June 1877 and was first demonstrated at the West India Docks, but it was not until late in 1878 that the first permanent installation consisting of six lamps supplied from a single Gramme alternator was established at the Commercial Ironworks of Wells and Co., Shoreditch, London.

The first attempt at electric street lighting in London on a practical scale was the experimental installation of twenty candle lamps along the Thames Embankment in October 1878, followed within a few weeks by similar trials on Holborn Viaduct and at the Mansion House. A private installation of sixteen Jablochkoff candles at Billingsgate Market in London went into service at the end of November 1878. The majority, if not all, of the early installations of electric candles in England were carried out by Société Générale d'Électricité, which later became the Compagnie Générale. This firm manufactured and marketed the Jablochkoff apparatus, which enjoyed considerable popularity for several years. The value of the lamp was enhanced by the use of copper-plated carbons, which were first patented in France by de Fontaine-Moreau in 1859, with the object of reducing the rate of burning; they were later manufactured on a commercial scale by F. P. E. Carré of Paris.

Many more British installations were completed in 1879, including London Bridge and St. Enoch (Glasgow) railway stations, Wills's tobacco factory at Bristol, the British Museum Reading Room, Pullars' dye works at Perth and Cammell's steel works near Chesterfield.

In England alone, the number of electric candle lights in use by 1881 is reported to have been in excess of 4000, but by this time the limitations of a non-regulating lamp were more fully appreciated, and the use of the Jablochkoff lamp gradually declined. Undoubtedly this inventor played a great part in the development of electric lighting. He had taken the first step towards 'the sub-division of the electric light', and his success inspired many others who undertook research in this field.

The Incandescent Lamp

The name of Sir Joseph Swan, F.R.S. (1828–1914) has been mentioned in an earlier article apropos of the lecture given at Sunderland in 1847 by W. E. Staite (1809–54), pioneer of electric arc lighting and the inventor of an early filament lamp. Both types of lamp

were demonstrated at the lecture, but it appeared to Swan that only with a satisfactory filament lamp could electric lighting achieve ultimate success.

Swan studied the somewhat limited literature available on the subject of earlier research, notably the work of Warren de La Rue (1815–1889), Sir William R. Grove, F.R.S. (1811–1896), and of course W. E. Staite. Early in his experiments he seems to have become aware of the difficulties associated with luminous filaments of platinum and iridium, and soon after 1848 he was working with narrow strips of carbonized paper. The initial experiments of Swan lasted some twelve years and were abandoned about 1860, by which time he realized, that although he had successfully produced a lamp with a strip-carbon element, further progress was barred by the limitations of voltaic batteries as a source of illuminating power and the primitive pumping equipment upon which he depended for exhausting his bulbs.

The invention of the mercury vacuum pump by Hermann Sprengel in 1865 and its successful employment by Sir William Crookes, F.R.S. (1832–1919) for applications demanding high vacua encouraged Swan to resume his work on the filament lamp in 1877, and within a year the first practical incandescent carbon-filament lamp was exhibited on the 18th December 1878 at a meeting of the Newcastle upon Tyne Chemical Society. It is sometimes pointed out that the lamp shown by Swan on this occasion was not working, but when the lecture was repeated on the 17th January of the following year the lamp was in operation.

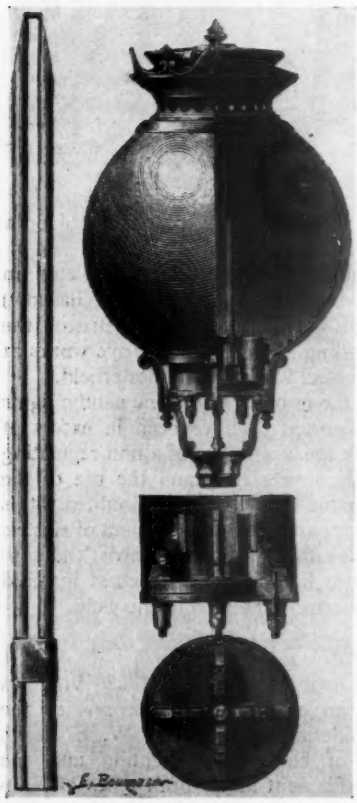
Swan had been fortunate in securing the collaboration of Charles H. Stearn of Birkenhead, who was familiar with vacuum-pump technique and who undertook to exhaust the bulbs of the first lamps.

Many difficulties were successfully overcome, but Swan's outstanding contribution to the ultimate success of the carbon-filament lamp at this period was the realization that the short life of his first lamps, in spite of the relatively high degree of evacuation of the bulb, was due to the liberation of air from the filament itself during early incandescence. His solution was to render the filament incandescent during the process of exhaustion and this formed the subject of his first lamp patent, January 1880. A Swan lamp is shown in Fig. 14.

Swan was constantly urged by his associate Stearn to protect his ideas, but this he was reluctant to do, holding the view that the basic features of an incandescent lamp had been anticipated and could not be protected by a valid patent. Instead, Swan concentrated his whole effort towards the production of his lamp on a commercial scale, and it is generally agreed that this started at the beginning of the year 1881.

That Swan's policy in respect of patent protection was unquestionably mistaken was proved by events. Not only were English patents successfully obtained by Edison, but the very fact that they were granted is interpreted by many American historians as proof of prior discovery.

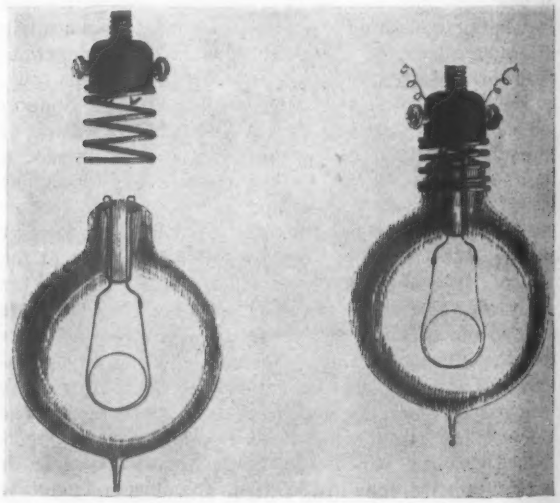
Another English lamp pioneer was St. George Lane-Fox (also known as Pitt), a prolific inventor whose series of patents began in 1878 with one for an incan-



13 *Jablochkoff electric candle, 1876*

The carbons and bridge piece are shown to the left of the lantern.

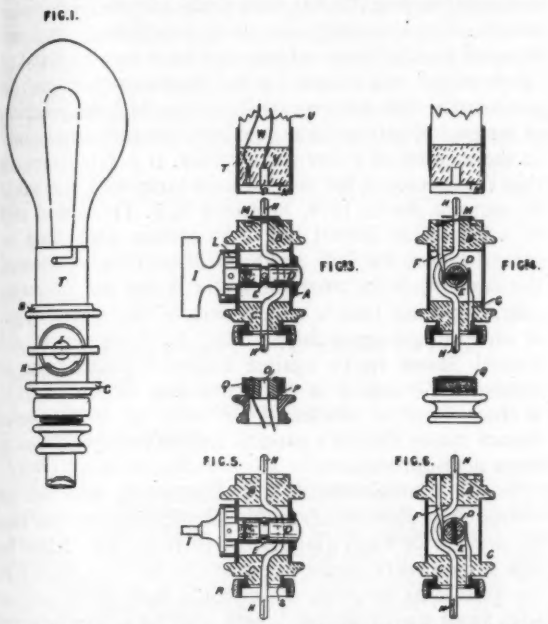
14 *Swan carbon-filament lamp with Gimingham's holder, 1880–81*



descent lamp with a metallic filament, and by 1882 his patented inventions included a vacuum pump, an automatic voltage regulator and several forms of integrating energy meter. Fig. 16 shows a lamp made by him.

Meanwhile in the United States, William E. Sawyer (d. 1883) and Albon Man, who started operations at the beginning of 1878, were working on various types of incandescent lamp, the majority of which were obviously impracticable.

In July 1878, the Electro Dynamic Light Co. of New York was founded with the object of exploiting the Sawyer–Man lamp projects. Their vacuum lamps having



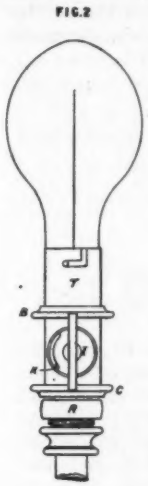
15 *The first bayonet cap and the first switched-lamp holder, designed by Coleman Defries, 1882*

proved unsuccessful, the inventors resorted to nitrogen-filled bulbs, which had been proposed by earlier experimenters, but such lamps possessed dubious commercial value.

The Sawyer–Man patents were principally of importance on account of a hydrocarbon-gas flashing process, by means of which the filaments then in use could be rendered uniform in thickness by the use of a controlled process securing a high degree of standardization. The English patent granted to Sawyer in November 1878 preceded the Washington patent of January 1879. The latter changed hands several times in the United States, and at a later date it acquired commercial significance in the American lamp industry far beyond anything foreseen by the patentees.

A New Use for Bamboo

The person responsible for the greatest initial progress in connection with the development of the incandescent lamp in the United States was without doubt Thomas Alva Edison (1847–1931). This famous inventor was formerly a telegraph operator, and it was in this capacity that he became acquainted with electricity. His early inventions were mainly concerned with the telegraph, and he was responsible for a number of improvements relating to the printing telegraph and multiplex systems. On the proceeds of earlier work, he established a laboratory at Menlo Park, New Jersey, in 1876, and it was here that towards the end of the following year he started experimenting with incandescent lamps. It is said that Edison first saw electric arc lighting demonstrated in 1878 at the electrical factory where the Wallace–Farmer dynamos were made, and that he immediately became obsessed with the idea that what had previously been the subject of casual laboratory experiment was now a matter of urgency. It appears that in the course of a few months, Edison's views upon the most suitable material for lamp filaments were reversed several times. In an interview with the *New York Tribune* in September 1878, he said 'I have let the other inventors get the start of me in this matter, somewhat, because I have not given much attention to electric lights; but I believe I can catch up to them now. I have an idea that I can make the electric light available for all common uses, and supply it at trifling cost, compared with that of gas. There is no difficulty about dividing up the electric currents and using small quantities at different points. The trouble is in finding a candle that will give a pleasant light, not too intense, which can be turned on or off as easily as gas. Such a candle cannot be made from carbon points, which waste away and must be readjusted constantly while they do last. Some composition must be discovered which will be luminous when charged with electricity, and that will not waste away. A platinum wire gives a good light when a certain quantity of electricity is passed through it. If the current is made too strong, however, the wire will melt. I want to get something better.'

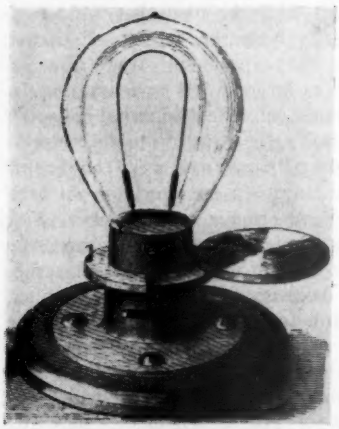


By the end of November 1878, Edison had abandoned carbon and returned to platinum, but by the autumn of 1879 he was again experimenting with carbon filaments and by the close of the year, production was commenced on a commercial scale. The material first used was carbonized paper, but a little later bamboo fibre was adopted and continued in use in the United States until 1894. The first samples of the Edison lamp were shown in London in February 1880 and on the Continent shortly afterwards. It was Edison's practice to patent as much as possible, and, in consequence, at the end of the year 1879 Sir Joseph Swan found himself hampered by

five English patents granted to his American competitor.

Swan established his lamp factory under the name of the Swan Electric Lamp Co. at South Benwell, near Newcastle, and at an early date was joined there by Charles H. Gimingham, who was responsible for the design of a greatly simplified mercury vacuum pump on the Sprengel principle, which was patented in 1882, and by C. H. Stearn.

When first produced, incandescent lamps were sold for more than a pound each, but within a year the price had fallen to five shillings. They were graded according to filament characteristics and were sold under the voltage for which they were suitable and the approximate candle



16 *Lane-Fox lamp and bayonet lamp holder designed by the Anglo-American Brush Corporation, 1884*
The bayonet cap was also patented by Gimingham in 1884.

power. At this period, elaborate records were kept and the performance on test of each lamp could be verified. It is of interest to record that an early order was for 25000 lamps for America, conditional upon execution within fourteen days.

By 1882, Swan's lamp interests had expanded considerably and the manufacture of lamps had started on the Continent under the control of Sir James Swinburne, BT., F.R.S. (b. 1858), who subsequently became President of The Institution for the year 1902. After the sale of Swan's American patents to the Brush Co. of Cleveland, Ohio, Sir James went to the United States in connection with the establishment of a lamp factory there. The manufacture of Swan lamps in the United States, by or under licence from the Swan Incandescent Light Co. of America, established in 1882, continued until shortly before the close of the century, when as a result of mergers it ceased to exist.

It was during 1882 that Swan expanded his company, which was re-formed under the style of the Swan United Electric Lighting Co. Within a matter of weeks, the new company was engaged in the preparation of its defence to an action brought by the Edison Co. for infringement of Edison's English patents. The American interests failed to secure an injunction in the English courts to prevent the manufacture of Swan lamps from continuing during the hearing, and soon afterwards what might have been an expensive legal battle was avoided by a negotiated settlement. It is well known that the two companies combined to form the Edison and Swan United Electric Light Co., the authorized capital of which was £1 million.

An Ignis Fatuus

By the end of 1882, the production of lamps in England was approaching 100000 per annum and thereafter rose steeply. The industry was well established, and the demand for the lamps which were known in England as 'glow-lamps' and in the United States as 'burners' (in accordance with Edison's desire to simulate the practices of the gas industry as far as possible), was sufficient answer to the sceptics of a few years earlier. It is fair comment that the success of the incandescent lamp took the world by surprise, for in 1878, Professor S. P. Thompson said in a lecture at Bristol that 'any system depending on incandescence will fail', and Sir William Preece expressed the same view in more emphatic terms the following year, declaring that 'a subdivision of the electric light is an absolute ignis fatuus'. Dr. E. Thomson in the United States spoke against Edison's experiments in similar terms and it is on record that as late as 1881 Werner Siemens declined the offer of a European licence under Edison's patents, having no confidence in these developments.

In his 'Reminiscences', Col. Crompton, who was an outstanding pioneer of electric arc lighting, admits that his preview of Swan's laboratory early in 1880, where he saw some twenty incandescent lamps burning, took him completely by surprise. Crompton's early collaboration with Swan was of mutual benefit, and for a time he acted as Chief Engineer of Swan's company.

It has been stated earlier in this article that the Swan lamps were first produced on a commercial scale at the beginning of 1881, but for at least twelve months prior to this, considerable numbers had been made under laboratory conditions. Crompton records that they were shown at an exhibition of gas-lighting plant held in Glasgow in the summer of 1880, and that from then onwards he was taking orders for generating plant for incandescent-lighting installations. Some of the earliest installations were, not unnaturally, in Glasgow, and included the main Post Office and a railway goods yard. In order of priority, the installation in Sir W. Armstrong's house at Cragside, Rothbury, followed the initial installation in Swan's own house at Gateshead. At Cragside, power was obtained from what is claimed to be the first hydro-electric plant in England, completed in December 1880. The name of Lord Kelvin had been associated with electrical illumination from the outset, and the wiring of his house was completed early in 1881. Kelvin declined official connection with the company but gave Swan much sound advice and the benefit of his

wide influence. This year was one of the most remarkable in the history of electrical illumination, for, apart from the many public buildings which adopted the new light, the first British ocean-going-ship installation was completed in the *City of Richmond*, and the Navy had ordered initial trials to take place in H.M.S. *Inflexible*. In the same year, also, Swan lamps were used in a main-line train between London and Brighton. Perhaps the most outstanding of the installations completed during this year was that in the Savoy Theatre, London, where 824 lamps were used on the stage and a further 370 in other parts of the theatre. Swan records that at a slightly later date, effective use of the incandescent lamp enhanced the delights of *Iolanthe*. The performers were themselves decorated with miniature lamps, but how the wiring was arranged on this occasion is not stated!

The filaments used in the early Swan lamps were made from cotton thread, treated with sulphuric acid before carbonizing. As already indicated, the results obtained were not consistent, and Swan's further research enabled him to adopt the plastic extrusion process using nitro-cellulose or nitro-glucose, which he patented in 1883. This not only revolutionized the English lamp industry, but led eventually to the discovery of artificial silk early in the present century.

It is interesting to trace the development of the lamp-holder, and there is no doubt that the screw cap adopted by Edison from the start of his activities was vastly superior to the system of wire hooks fitted to the first English lamps. The bayonet cap which at an early date was adopted by the English manufacturers, appears to have been introduced by Coleman Defries and is one of the features of his patent of May 1882, in respect of a switched lampholder. It was repatented by Gimingham in 1884 and there is evidence that it was used by the Anglo American Brush Corporation around 1884.

CORRESPONDENCE

INFORMATION INPUT TO COMPUTING MACHINES

From G. A. MONTGOMERIE, B.SC., A.M.I.MECH.E., ASSOCIATE MEMBER

Much has been said recently about the rate of input of information to computing machines, particularly those designed for business use. Most of the work on the subject has aimed at increasing the input to the machine from some recording medium, such as punched tape or magnetic tape; this, however, is only part of the whole input process. It is true that some information can be recorded on tape as a by-product of some other operation, but much will have to be recorded specially by a human operator. Faster tape readers may enable a computing system to accept input from many operators at once, but the real bottle-neck may well be the initial recording of information on tape by the operator.

At present, the usual way of coupling the operator to the tape preparation unit is by a keyboard, and for 'alphanumeric' information this is rather like an ordinary typewriter keyboard. Touch operation is possible with comparatively little training, but the rate of information input is limited by the rate at which an operator can strike successive keys.

A very much greater rate of input might be achieved if it were made possible for an operator to strike a 'chord' of several successive characters instead of just one character at each stroke. For this to be done, the keyboard would have to be replicated as many times as the number of characters to be inserted at each stroke; unfortunately, with conventional keyboards, this would mean covering too great an area to allow touch operation, even if the operator could 'reach' all the 'chords' required.

This difficulty could, however, be circumvented. Consider a specific case in which it is sufficient to have a choice of 35 characters in each alphabet (the 26 letters and the ten digits but using the same symbol for zero as for the letter O). Such a set of characters can be provided on a condensed keyboard of only six keys, arranged conveniently in two columns of three for operation by a pair of adjacent fingers. Each finger can, in its own column, depress: no key; the upper key; the upper and middle keys; the middle key; the middle and lower keys; or the lower key. This gives 36 combinations, or 35 if we exclude (as we may have to) the case of no key depressed in either column. These different combinations can be allocated to the different characters of the alphabet in use, and a particular character is signalled by depressing a particular combination of keys with a pair of fingers.

The six keys would be replicated four times (24 keys in all), and each set of six would be controlled by its own pair of adjacent fingers. In this way a 'chord' of four characters could be inserted at each stroke, and scanned serially and interpreted by the machine.

Each alphabet would cover the area of six keys only, and each finger would have to depress at most two vertically adjacent keys at once so that all the necessary 'chords' could easily be 'reached'. In this particular arrangement the thumbs could be reserved for special control keys.

With some such scheme, the rate of information input from an operator to a machine could be made several times as great as with a conventional keyboard, and though the first application which springs to mind is to computing machines, no doubt similar arrangements could be applied to almost any keyboard-operated machine. With a greater or smaller number of characters in the required alphabet, more or less than six keys would be required. For example, if the ten digits 0 to 9 only were to be handled, it might be feasible to insert one for each finger instead of one for each pair. However, the same basic principle would always apply, of condensing the keyboard for each character by allowing some characters to be represented by depressing simultaneously two or more keys, and then replicating this condensed keyboard so that more than one character could be inserted at a time.

Over and on the Transatlantic Telephone Cable

A historic discussion in January with the American and Canadian Institutes

EVERYONE present at the meeting in The Institution's Lecture Theatre on the 24th January this year must have had a sense of history in the making. This was the first occasion on which America, Canada and Britain had been linked by the new transatlantic telephone cable for a joint meeting—attended by some 1 350 people. The meeting was in fact a discussion between the American Institute of Electrical Engineers in New York, the Engineering Institute of Canada in Montreal, and The Institution in London, on a dozen papers about aspects of the transatlantic telephone cable itself. This use of the equipment under discussion, for the business of the meeting, manifested a great engineering feat to those present in a way that can seldom have been paralleled. High-fidelity music recordings were kindly provided by the B.B.C., whose engineers worked in conjunction with the Post Office throughout the programme. The clarity and immediacy of the speeches from America and Canada were almost uncanny, and to at least one observer in London it appeared that the recorded music played over the cable from America during the meeting had a slightly higher quality, as heard in the Theatre, than the same music reproduced in London.

The papers were presented in scripted surveys by certain of the authors—American, Canadian and British—and at its close, when the cable link was removed, local unscripted discussions took place independently before the three societies. A full list of the papers was given in the January *Journal*, p. 38, and, as previously announced, these papers have recently been published in a special supplement to Part B of the *Proceedings*, together with part of the joint discussion and with all the London local discussion of them. An article about the cable in the light of information given in the papers appears on p. 327.

The meeting in January opened with greetings between the Presidents of the three societies concerned: Mr. V. A. McKillop, President of the Engineering Institute of Canada; Dean M. S. Coover, President of the American Institute of Electrical Engineers; and Sir Gordon Radley. Dean Coover, with the support of Mr. McKillop, then asked Sir Gordon to act as Chairman for the meeting. After Sir Gordon had expressed his willingness to do this, he called on Dr. M. J. Kelly in New York to introduce the subject of the meeting.

Dr. Kelly gave a brief introduction to the cable system, during the course of which he paid a tribute to the foresight and early contributions made by Dr. Buckley and his associates: 'It was their anticipation of the future need for a telephone cable system which resulted in the long development and testing programme that made available to us a mature art at the time it was needed.' He was followed by Mr. R. J. Halsey, who described the main features of the system, dealing particularly with the various types of link that make up the complete connection between Great Britain, Canada and the United States. Other authors of papers who spoke were Mr. E. T. Mottram, Mr. J. S. Jack, Mr. H. A. Lewis, Mr. A. W. Lebert and Mr. T. F. Gleichmann in New York, Mr. R. G. Griffith in Montreal, and Captain W. H. Leech and Dr. R. A. Brockbank in London. Sir Gordon himself made some brief contributions to the survey of the technical content of the papers that occupied

Part of the dais of The Institution's Lecture Theatre during the Joint Meeting at which the transatlantic telephone cable was discussed. A wall chart behind the President's chair illustrates the British-designed repeater; a column (line-source) loudspeaker may be seen to the right of the doorway

Mr. R. J. Halsey speaking at the meeting, with Dr. R. C. G. Williams, Chairman of the Radio and Telecommunication Section on his right, and Dr. R. A. Brockbank on his left

this part of the meeting, and at the close of Dr. Brockbank's contribution he asked Mr. Halsey to announce the names of the other authors of the papers.

Sir Gordon summed up the survey of the papers, and then invited Sir Archibald Gill, because of his particular interest in the cable, to say a few words in retrospect. Sir Archibald stressed the commercial courage of those responsible for putting the vast project in hand. He recalled that, during his service with the Post Office, he had been concerned with the specification of the *Monarch*, the cable-laying ship used for the transatlantic cable, and he felt that this specification, although apparently a little lavish at the time the *Monarch* was laid down, had now been fully justified.

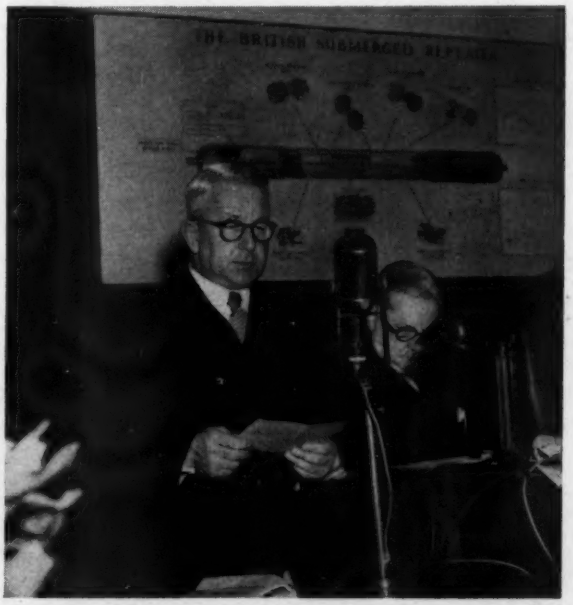
Mr. Eadie, President of the Bell Telephone Company of Canada, speaking from Montreal, said that as an engineer who had spent his working life in the telephone business he had been listening with particular fascination to the discussion. It brought sharply to mind the tremendous research effort. On the one hand they had co-operation between the United States, Britain and Canada, on the other, co-operation in depth within the communication industry. There was particular appreciation of the cable in Canada. 'We Canadians are a very telephone-minded people. . . . Canada to-day stands next to the United States and the United Kingdom in the total number of its telephones.' He then introduced Mr. D. F. Bowie, President and General Manager of the Canadian Overseas Telecommunication Corporation, who said that the tremendous achievement in the communication field that the new cable represents was the product of engineers and one of which they could be justly proud. Sir Gordon, in thanking Mr. Bowie, remarked that they had been together on the previous day in London and that it was not easy to believe Mr. Bowie was now back in Montreal.

Mr. Chester Lawton, of the Western Union Telegraph Co., in New York, was the next speaker. He outlined some of the contributions of his company to the laying of the new cable, by advising about the route and carrying out experimental work in the company's cable ships, particularly the *Lord Kelvin*. This ship laid the two coaxial telephone cables between Key West and Havana in 1950, which contained prototypes of the flexible repeaters used in the transatlantic cable.

The two Presidents in New York and Montreal then made short speeches closing the meeting. Dean Coover spoke as follows: 'And now, as the moment approaches for adjournment of this tri-national technical session by transatlantic submarine telephone cable, I want to express on behalf of the American Institute of Electrical Engineers our deep gratitude to all who have made it possible to hold this eventful session to-day. We are confident that as greater use is made of this more effective means of communication among the peoples of Great Britain, Canada and the United States, the bonds of friendship and understanding, both social and political, will continue to strengthen. The same may be said of the peoples of other nations who will have access to this new and dependable means of communication. The interchange of voice communication can be profoundly effective; it can have far-reaching influences in stabilizing peaceful living among men and nations around the globe.

'We who are assembled here in New York are delighted over the opportunity to participate with our friends in Montreal and in London in this history-making event. Our very best wishes go from all of us to each and all

Captain W. H. Leech, Submarine Superintendent of the Post Office, talks about the selection of the route and the terminal points for the cable



of you who are assembled in London this evening and in Montreal this afternoon.'

Mr. McKillop said: 'It has been a privilege to join with our two great sister Institutions in the world's two greatest cities to discuss a great and unique engineering achievement. Man's achievements in science, man's ingenuity, are applicable to the arts of war as they are to the arts of peace. Our meeting to-day brings to public attention a further contribution of the engineer and scientist to the cause of peace.

'I like to think of these many wires beneath the sea as holding our countries together, keeping us from drifting apart, and at the same time providing the means of easy communication to prevent misunderstanding.

'It is something unique in this troubled world that three great nations can be bound together so closely by mutually acceptable ties, that they speak the same language and that they can meet to-day on this historic occasion to discuss only the works of peace. This transatlantic telephone cable will contribute much to our continued good relations. Is it too much to hope that in some way our pattern for peace, our interest in the welfare of the world, will help other nations to come together in friendly accord?'

They were followed by Sir Gordon Radley, who said: 'And now I . . . declare this joint meeting closed. And, in so doing, I thank all those who have collaborated in making it so successful. Good afternoon New York. Good afternoon Montreal.'

Thus ended a remarkable and inspiring meeting, a forerunner, one hopes, of many joint meetings with our American and Canadian friends. And to our minds come tantalizing visions of the first joint meeting over a transatlantic television cable—giving each society sight of the speakers from the other two, as well as the sound of their voices.

THE KELVIN LECTURE MEETING

Two new Honorary Members and the 1957 Faraday Medallist receive Presentations

THE Kelvin Lecture Meeting, held this year on the 4th April, followed the customary pattern. The principal item in the evening's programme, the delivery of the Forty-Eighth Kelvin Lecture by **G. B. B. M. Sutherland, Sc.D., F.R.S.,** Director of the National Physical Laboratory, was preceded by presentations to two new Honorary Members of The Institution, **Sir Noel Ashbridge, B.Sc.(Eng.), Past-President,** and **Brigadier-General Sir Harold Hartley, G.C.V.O., C.B.E., M.C., M.A., F.R.S.,** and to the Faraday Medallist for 1957, **Dr. Waldemar Borgquist.** The Page Prizes and the Institution Prizes for 1956 were also presented to students who had won them. There was an attendance of several hundred members and guests at the meeting, and the Lecture Theatre was comfortably filled.

After making an announcement about the subscriptions and donations to the Benevolent Fund received in March, the President welcomed a large number of new Corporate Members with the customary short ceremony. He then said that it was his privilege and great pleasure to present certificates recording Honorary Membership of The Institution to two new Honorary Members and to present the Faraday Medal for 1957.

He spoke first about Sir Noel Ashbridge. Sir Noel was educated at Forest School and King's College, London. He received his engineering training with Yarrow and Co., and with the British Thomson-Houston Co. at Rugby, where in 1912 and 1913 he was in charge of turbo-alternator testing.

At the outbreak of the First World War he joined the Royal Fusiliers and was posted to France in July 1915. Later he transferred to the Royal Engineers at a time when the army were seeking technically trained personnel for wireless-telegraphy duties. Sir Noel's diversion from heavy- to light-current engineering may be said to date from this time.

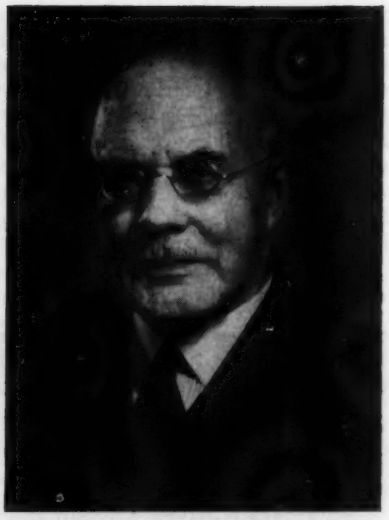
Soon after the conclusion of the war Sir Noel Ashbridge joined Marconi's Wireless Telegraph Co. It was during his period at the Writtle experimental station that he took part in the first regular broadcast transmission in this country.

His appointment in 1926 as Assistant Chief Engineer to the B.B.C. marked the beginning of some twenty-six years' work in the interests of broadcasting, during which time he became successively Deputy Director-General and, in 1948, Director of Technical Services.

Under Sir Noel's direction a chain of high-power broadcast transmitters augmented and eventually replaced the low-power stations formerly used. With the advent of television, his membership of the Television Committee in 1934 enabled him to help in the inauguration of a worth-while service.

Sir Noel Ashbridge

Dr. Waldemar Borgquist



Sir Harold Hartley

The Second World War put an end for the time being to television broadcasts, and numerous precautions already planned with Sir Noel's guidance were brought into service to prevent the British broadcasting stations being used as homing beacons by enemy aircraft.

After the war Sir Noel's experience and guidance were invaluable to the Television Advisory Committee in formulating their views on the subject of picture definition.

His services to British broadcasting were recognized in 1935 by the conferment of a knighthood. Earlier, the honour of knighthood of the Royal Order of Dannebrog had been conferred upon him for his assistance in the establishment of the Danish broadcasting system.

Sir Noel was elected a Member of The Institution in 1933 and in the following year was elected to the Council. On the completion of his three-year term of office as an ordinary Member of Council he was elected a Vice-President, and in 1941 President.

He has served on numerous Institution committees, including the Court of Governors of the Incorporated Benevolent Fund, and in 1948 he presented the Faraday Lecture on 'Television'. He has been Chairman of the Radio Research Board. On retirement from the B.B.C. in 1952, Sir Noel returned to industry, where he now holds a directorship of Marconi's Wireless Telegraph Co.

When the President had ended his oration, Sir Noel Ashbridge signed the Book of Honorary Members and Faraday Medallists and received a Certificate of Honorary Membership from the President. In replying, he said that he found it difficult to express his deep appreciation of the honour in a way which did not sound commonplace. Nevertheless he could only ask the President and Members of Council to accept his expression of real appreciation and gratitude.

He cast his mind back to the days when he became a Member of Council—a landmark in the career of any electrical engineer. The Institution was in 1934, as in 1957, a highly respected body; but it was different in many ways. For one thing, the membership was some 16 000, compared with the present figure of about 41 000. Looking back, Sir Noel thought that The Institution had then been slower to make changes; its activity did not expand as rapidly as members were used to at the present time.

It was not because national affairs were any more settled than they were to-day. The country was just feeling the effects of abandoning the gold standard, and there was the ever larger cloud of war becoming each year more serious. Within a few years of course the latter became a reality. But it was during those years that The Institution seemed to generate new vigour and became of wider importance in the industrial life of the nation.

In the early days of the war he had been honoured by being elected President. In some ways he had always regretted that the honour came at that time, because it prevented him from carrying out all the normal functions of a President; the social activities in particular had to be very considerably curtailed. Not that The Institution had not very fully played its part in trying to solve the special problems of a very difficult period. Sir Noel recalled the many committees set up to deal with the provision of more power for industry. Then there were matters connected with call-up and deferment. And he remembered well the formation of R.E.M.E., which took place during his year of office and in which The Institution—quite rightly, he thought—became involved.

Before he closed Sir Noel again expressed his warm appreciation of the great honour conferred on him.

The President next spoke of Sir Harold Hartley, who has held high office in no less than four of our major industries—railways, fuel, airways and electricity supply

and has been responsible for advising all of them on research. For thirty years he was Natural Sciences Tutor and Bedford Lecturer in Physical Chemistry at Balliol College, Oxford. During the First World War, after service with the Leicestershire Regiment, when he was awarded the Military Cross and three times mentioned in dispatches, Sir Harold was appointed Chemical Adviser to the Third Army, Assistant Director of Gas Services, G.H.Q., France, and subsequently Controller of Chemical Warfare in the Ministry of Munitions.

In 1931 Sir Harold took up important posts in industry, first as Vice-President and Director of Research

Sir Noel Ashbridge speaks in the Lecture Theatre after signing the Book of Honorary Members and Faraday Medallists

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of the L.M.S. Railway and, in 1934, as Chairman of the Railway Air Services as well. In 1946, he became the first Chairman of British European Airways and in 1947 Chairman of the British Overseas Airways Corporation, a post which he held until 1949.

In 1949 he became Chairman of the Electricity Supply Research Council of the British Electricity Authority, holding this office until 1952, when he finally retired from executive responsibility in industry.

Sir Harold's retirement is in name only, for he is still a director of the Times Publishing Co., Scientific Adviser to Costain–John Brown Ltd. and editor of the Royal Society's 'Notes and Records'.

He was President of the World Power Conference from 1950 to 1956, having been Chairman of its International Committee since 1935. He was President of The Institution of Chemical Engineers in 1951–52 and in 1954–55. In 1955 he was appointed Chairman of the O.E.E.C. Commission on the Future Energy Requirements of Europe.

As Chairman of its Council, he organized the Duke of Edinburgh's Study Conference on the Human Problems of Industrial Communities within the Commonwealth and Empire, held in Oxford last summer.

In recent years he has given the Fawley Lecture at Southampton, the Graham Clarke Lecture on 'The Engineer's Contribution to the Conservation of Natural Resources' and a Friday evening discourse on 'World Population and Resources' at the Royal Institution.

He has published numerous papers on chemistry and industrial research. He became a Fellow of the Royal Society in 1926, was knighted in 1928, created K.C.V.O. in 1944 and G.C.V.O. this year. Many honorary degrees have been conferred on him. He was President of the British Association for the Advancement of Science in 1950.

Like Sir Noel Ashbridge, Sir Harold signed the Book of Honorary Members and Faraday Medallists, and received a Certificate of Honorary Membership. He then said that it was not easy to thank the President and the Council of The Institution adequately for the very great honour that they had done him. He could only tell them how much he appreciated it, and he could say that few things in life had given him greater pleasure. So much of his work had been associated with electricity and engineering, and he had had so many friends in The Institution during the last forty years, to whose encouragement and help and advice he owed so much. Sir Harold wanted just to mention one of them who was no longer with them, because they had had a special association together —Charles Fairbairn. He was the Chief Electrical Engineer on the L.M.S. Railway and later Chief Mechanical Engineer. He gave the railway very valuable services. His paper on the Diesel-electric locomotive was a milestone in preventive maintenance. Sir Harold always much regretted that Fairbairn died before there had been any adequate recognition of what he had done.

Sir Harold said that he was going to let them into a secret—'just to show you my heart has always been in the right place'. Thirty years ago there had been a rather critical position over the election of the first Reader in Electrical Engineering at Oxford. With Lord Lothian's help, he had obtained a letter to the Vice-Chancellor which said that the Rhodes Trustees would be responsible for the payment of the salary of the Reader on two conditions. The first was that Dr. Moullin (a future President of The Institution) should be the first Reader. The second was that Sir Harold would undertake to raise the capital. Doing that was not easy. But with the help and advice of his wife and the generosity of Sir Donald Pollock they had entirely liquidated the debt.

Sir Harold had the greatest admiration for The Institution. He knew of the great contribution The Institution had made to their profession, and it had always been such a pleasure to come to meetings in 'this beautiful room'. Members had always made him feel

The President congratulates Sir Harold Hartley as he hands him the Certificate of Honorary Membership of The Institution

very welcome, and now it was a real thrill to him to feel that in future he should belong there.

After the presentations to the Honorary Members, the President said that it was now his very pleasant duty to make the thirty-fifth award of the Faraday Medal to Dr. Waldemar Borgquist. Dr. Borgquist was born at Malmö, Sweden, in 1882. Graduating at the Royal Institute of Technology in Stockholm in electrotechnology in 1903, he received further training with the Luth and Rosens Electrical Co. in Stockholm, and with Siemens-Schuckert in Berlin. In 1908 he was appointed plant engineer at the Trollhettan power station. In 1911 he became Head of the Power Station Section of the Swedish State Power Board. He was appointed Chief Engineer in 1914, Director in 1919, Chief Director in 1920, and Director-General and Head of the Power Board in 1938, an appointment which he held until his retirement in 1947.

Dr. Borgquist thus served in key positions throughout the first four decades of the Board's existence, and his individual touch contributed greatly to its shaping and development. Largely as a result of his work, Sweden has become a leading nation in the field of power distribution. Dr. Borgquist represented the Power Board with outstanding skill, secured the use of a number of waterfalls in competition with other interests, planned distribution schemes, introduced rational tariffs, organized rural electrification, and collaborated with other power companies. He was concerned in the introduction of a standard 50c/s supply, the development of long-distance bulk transmission at 380kV a.c. and at high voltage d.c. He is also an authority in all fields of civil engineering.

In his work for the Power Board, Dr. Borgquist placed great emphasis on the value of teamwork and took great care in selecting the working teams for important tasks, but the results obtained were invariably due to his directives and his critical assessments.

Dr. Borgquist's skill and experience have been widely employed in Swedish industry generally. He was formerly a member of the board of Luossavaara-Kirunavaara Ore Co. and Chairman of L. M. Ericsson Co. He has been Chairman of the Swedish Aluminium Co. since 1950 and Chairman of the Swedish Radio Corporation since 1953. He is a member of the Swedish Academy of Engineering Sciences, and was President from 1941 to 1944. He is a member of the Physiographical Society in Lund; Chairman of the Meteorological and Hydrological Council; and a member of the Council of the Swedish Industries' Standardization Commission and of the Swedish Electro-Technical Committee.

In other countries Dr. Borgquist is well known. In 1924 he was called in by the Irish Free State for expert advice on their electrification programme, and in 1947 by Egypt for the Aswan project. He was one of the founder members of C.I.G.R.É., of which he became an early Vice-President.

The President ended his panegyric on Dr. Borgquist with these words:

'Dr. Borgquist has always shown great interest in the rising generation and has done much to ensure the provision of adequate facilities for education and training. His contributions in the field of power distribution and his pioneering work in the development of high-voltage power distribution stand in his own country and throughout the world as the monuments of a man of tireless energy, inventive mind and charming personality, whose presence is welcome and whose opinion is valued in electricity supply circles the world over.'

Dr. Borgquist then signed the Book of Honorary Members and Faraday Medallists and received the

Mr. P. Jarvis, who studied at Nuneaton Technical College, receives one of the two Page Prizes awarded in 1956

Faraday Medal and an accompanying scroll from the President.

In reply, Dr. Borgquist said: 'Life has been friendly to me. The development of the great hydro-electric schemes commenced in Sweden just about the time when I took my degree as an electrical engineer. I had the great luck to be engaged five years later as a member of the staff at Trollhettan, the first State power station in Sweden, and I think the greatest water-power station in Europe at that time.

'From then on I was to work continuously with the expansion of the Swedish electrical power supply, and when in the 'forties it became urgent to introduce an extra-high voltage in Sweden I had, on account of my position, to take care of that interesting problem. Now, as a precious crown to it all, I have received the Faraday Medal. England, with its great achievements in so many fields of human endeavour, has for me always been the heart of the world. I am therefore particularly happy that it is from England and from this Institution that I have received this high reward.

'I have just looked on the effigy of Michael Faraday on the medal. This fascinating man, so great in science, so rich in mind and heart, combining an ingenious intuition with an accurate judgment, made a contribution to the development of electricity greater, I think, than anyone else. I cannot conceive that to me and to any other electrical engineer it could fail to be a source of pride—although possibly to one's own surprise—to receive the Faraday Medal.

'At an early stage Sir Archibald Page made me acquainted with the plans for the British Grid. Ever since, I have followed with great interest the history of the British power supply and the success it has had in spite of the difficulties after the war, which were so energetically overcome. In Sweden we look with great admiration upon the favourable results gained by Britain in the development of electricity, and lately in the nuclear field particularly.

'We have received in Sweden so much valuable experience from England. If we have made a contribution to the development of power supply which is useful here also, we are very pleased.

'I beg, Mr. President, to express my sincere gratitude for the great honour bestowed on me.'

The President then presented the Page Prizes for 1956 to Mr. K. G. Burling, of Reading Technical College, and Mr. P. Jarvis, of Nuneaton Technical College. The Page Prize is won by the best of those candidates who obtain distinctions in all the compulsory subjects of the final year of the Higher National Certificate in Electrical Engineering. This year there were so many good candidates fulfilling these requirements that the Committee, after considering the report of the moderators, felt unable to decide on one candidate alone. Most unusually there were therefore two Page Prize-winners in 1956.

The Institution Prizes were then presented to students residing in the London area. An Institution Prize is won by a candidate who obtains not less than 85% of the grand total of marks in the final year of the Higher National Certificate or the Higher National Diploma in Electrical Engineering, and who was under 26 years of age on entry to the final year. In all, 57 students qualified for a prize in 1956.

*Dr. G. B. B. M. Sutherland delivers his Kelvin Lecture on '*Infra-Red Radiation*'*

The President then called on Dr. G. B. B. M. Sutherland to give the Forty-Eighth Kelvin Lecture on 'Infra-Red Radiation'. He began by describing the experiments of Herschel in 1800. Herschel placed a mercury thermometer in various parts of the visible spectrum, and found a larger rise in temperature when the thermometer was placed just beyond the red end of the spectrum. Next Dr. Sutherland considered some of the many methods used for detecting infra-red radiation. These have been classified under two main headings, photo-detectors and thermo-detectors, with six subdivisions in each, such as photochemical, phosphorescent, photoconductive, thermo-electric, bolometric and pneumatic. Thermo-detectors are in general sensitive to all infra-red wavelengths, whereas photo-detectors are usually sensitive only for wavelengths up to about 10μ. The lecture continued with an account of infra-red spectroscopy, with its applications to investigating molecular structure, atmospheric and solar gases, and the structure of diamond crystals. Dr. Sutherland ended with a discussion of infra-red analysis of proteins and the nucleic acids occurring in genes. The lecture will be published in full in Part B of the *Proceedings* later this year.

At the end of the lecture a vote of thanks to Dr. Sutherland was proposed by Sir Harold Bishop and seconded by Sir Hamish Maclaren.

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Voices under the Sea

An Appraisal of the Transatlantic Telephone Cable

On the 24th January 1957 The Institution, in London, was linked with the American Institute of Electrical Engineers, in New York, and the Engineering Institute of Canada, in Montreal, to hold a joint meeting for the discussion of a dozen papers devoted to the link itself—the first trans-atlantic telephone cable. A brief account of the meeting appears on p. 320. In this article some of the highlights of this great achievement of the cable are picked out against a backcloth of the past, and we look for a moment into the future.

THE North Atlantic has ever been a challenge. Even when the earth was most assuredly flat, men were impelled to find out what lay beyond the horizon, and men still face its dangers in small boats rather than the comfort of luxury liners and aircraft. Yet, for all its moody unpredictability, the Atlantic is the great artery of commerce between the two great continents it separates. Commerce—communication: the two are inseparable. It was word of mouth—personal contact between individuals who crossed the ocean to buy and sell—until the regular mail service began to draw the nations closer. From sail to steam, and into the air, letters which a century ago could not produce a reply for months can now bring answer in a week. With speed grew commerce; more commerce demanded faster communication; the two grow together.

In 1866 the Atlantic yielded to the telegraph cable; question and answer spanned the ocean within a working day. Again the demand grew, until a score of cables now link the two continents. Then, in 1927, came radio-telephony; travelling often faster than thought itself, signals flashed across the ocean, bringing back answer with no more delay than were it coming from the next street.

There remained at least one further step—a telephone cable—and this was accomplished in 1956. A long telephone cable of course needs repeaters in it at intervals to compensate for the transmission losses. For overland circuits these repeaters are easily accommodated, but the imagination boggles at the idea of 'installing' electronic equipment on the sea bed, anything down to 2½ miles below the surface; while the problem of maintenance—involving, as it will, locating a faulty repeater, bringing it to the surface, repairing and relaying it—savours of fantasy.

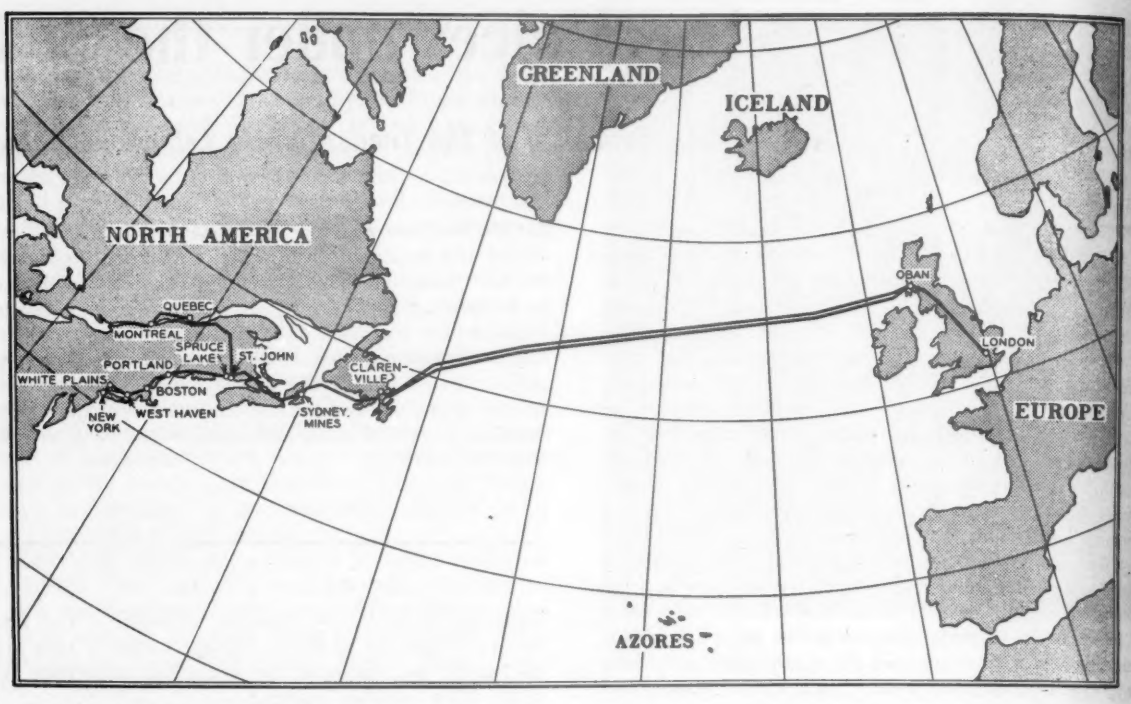
What, then, was the background which made the designers so certain that they could achieve their objective? To answer this we must recall that the venture is primarily a joint effort of the British and American telephone services, and examine the experience of each separately. In Britain, submarine telephony has been much influenced by the shallow waters of the continental shelf and the relatively short distances involved, so that unrepeatered cables can be used successfully. In 1943 the British Post Office inserted repeaters in a submarine cable, that between Anglesey and the Isle of Man, and after the war the Post Office greatly increased the traffic capacity of its Continental cables by inserting repeaters in them. In 1948 they began practical studies of deep-water cables, culminating in the 300-mile repeatered link with Scandinavia, planned as a prototype for a possible transatlantic cable. No less an influence is the long history of damage to British cables caused by trawling, anchoring, etc., reflected in a marked preference for single-cable two-way systems.

In America, on the other hand, the transatlantic telephone had long fired the imagination, so that developments centred on laying and maintaining cables and repeaters in depths where the pressure problems were greater, but the human hazards fewer, than in Europe. From this evolved the two-cable one-way system which first came into operation between Key West and Havana in May 1950.

The Foundations

As long ago as 1934 the Bell System approached the British Post Office with a proposal for a non-repeatered transatlantic cable to provide a single telephone circuit, but the project was shelved. In view of interim developments, however, negotiations were reopened in 1952 to discuss a transatlantic telephone cable, this time with repeaters. High-level agreement was based on the principle of complete co-operation and the use of the best available experience, and teams from both sides discussed their systems with a frankness unusual in international negotiations.

One of the first points to be resolved was the route, and from the start it was agreed to keep clear of the areas already congested with telegraph cables. Again, the participation of Canada in the scheme suggested a preference for a northerly route, while the limitations of sites available for terminal stations further narrowed the choice. After all factors had been considered it was agreed that the main cable should run between Scotland and Newfoundland, then across to Nova Scotia; thence transmission would be by radio link to Maine, to join



1 *Route of the transatlantic telephone cable system*

the United States inland network, the Canadian circuits taking off by open-wire carrier from a point in New Brunswick (Fig. 1).

Basically, then, the whole transatlantic link would fall into three parts, and after considering the experience available the three parties agreed to use the American twin-cable system for the 1940-mile* transoceanic crossing itself and the British single-cable system for the shallower 326-mile run to Nova Scotia, while the Americans and Canadians jointly would be responsible for the radio link. With these decisions established, the official agreement was signed on the 27th November 1953, setting the 1st December 1956 as the date by which the link was to be opened for public service. Without doubt, one of the factors which contributed most to the success with which this venture has already been crowned was the decision—taken at the first joint technical meeting—that each problem which arose would be solved on the best engineering basis, without consideration of national pride.

Having brought the project thus far, we can now look at some of the details, although it would be invidious to single out any particular part for special attention: indeed the link was 'christened' by an intercontinental meeting called to discuss a dozen papers covering the technical details, and each of these included references to earlier papers showing how the backgrounds developed on both sides of the Atlantic.

* These are nautical miles, one of which equals 1·153 statute miles.

The Cable

While most of the 4500 miles of cable required was manufactured in England, at a new factory specially built to make submarine telephone cable, much of the design basis came from the deep-water cables developed for the links between Key West and Havana and between Florida and Puerto Rico. A coaxial structure was adopted, with a composite central conductor, a high-molecular-weight polythene core insulation and an outer conductor of six copper tapes wound helically to impart flexibility. Without doubt, the greatest single influence on the design and manufacture was the great lengths involved, for it was essential that the cable losses should be, not only as low as possible, but as close to the specified values as possible throughout the length as human endeavour could make them: this was very important, for the gain characteristics of the repeaters were precisely designed to compensate the losses of the cable, and any departure from the agreed tolerances would therefore upset the whole system. The closest possible control over every raw material used and every stage of manufacture was therefore imperative.

Since the sea-bed conditions and depths are far from uniform over the route, three types of cable were used, differing only in the armouring employed. For the ocean depths themselves the major hazard is laying tension, so that an armouring of comparatively small-diameter high-tensile wires suffices (Fig. 2); while in really shallow waters even the best protections so far devised yield to

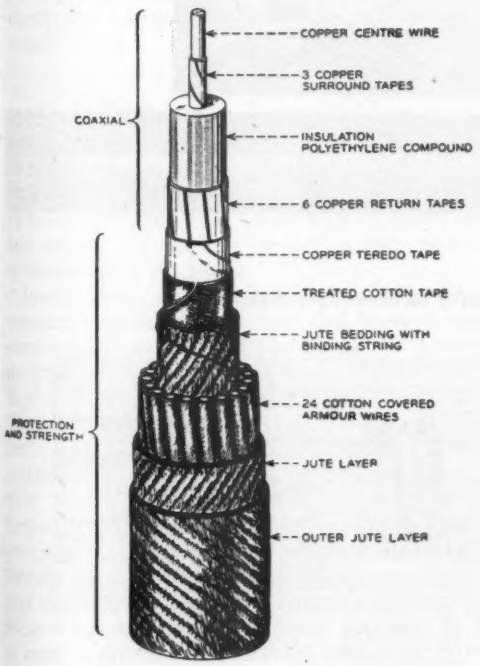
damage from trawls, anchors, icebergs, rocks and swift currents—to mention but a few of the hazards in the life of a submarine cable.

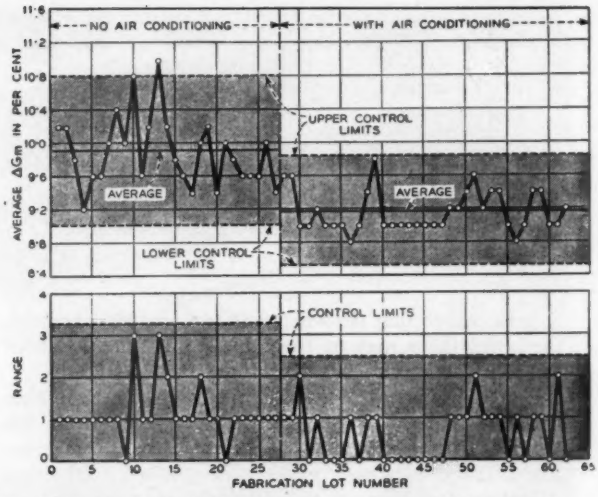
Despite the closest possible control, there was one possible source of trouble which was not amenable to factory discipline—an unpredicted decrease of attenuation with laying discovered when the test cables were laid off the coast of Spain. While this is no bad thing when fully allowed for, it could gravely upset the repeaters, so far below the surface. Due allowances for the effect have been made in both transatlantic cables, but there is evidence that the attenuation is still decreasing slowly two years after laying.

The Submerged Repeaters

To anyone in the least familiar with electronic equipment, the idea of a complex amplifier which would operate continuously, without maintenance, for 20 years may seem quite ludicrous. Add then to this the proviso that it must be small, yet must always withstand external pressures of nearly 7000 lb/in², and the concept borders on the impossible. But to-day there are 102 such amplifiers in the main cables, and the men and women who designed and built them are confident that they will not fail. Indeed, not content with solving these problems, they added some of their own when they decided that the submerged repeaters must be flexible and so nearly like the cable itself that they could be laid without stopping the cable ship.

2 *Structural features of the deep-water type of cable*



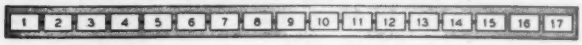


3 *Control chart showing the effect of air cleaning on the cathode activity level*

The percentage change in transconductance for normal heater current and a value 20% lower is used as a measure of cathode performance.

Nevertheless, none of these problems—except, perhaps, the great pressures—was entirely new, and once again the Key-West–Havana cables proved the testing ground for the concepts. The whole philosophy behind the electrical side of the design, however, was influenced by the enormous cost of rectifying a fault should one ever occur; reliability of an order beyond that previously conceived had to be the aim, and, indeed, had to be achieved. So the designers gave little thought to the new developments in the art—e.g. transistors, and miniature components—which would have made flexibility so much easier to achieve; instead, they turned to components with a long history of proven integrity, and settled down to improve upon an already high standard of reliability by a closeness of quality control and supervision that set new standards for perfection. A new factory was opened in the attractive surroundings of Hillside, New Jersey, its staff recruited for suitability and integrity and inculcated with the philosophy of perfection and self-criticism. Indeed, so close was the control of quality exercised that it was possible to pinpoint the day on which air-cleaning and -conditioning were introduced from inspection of the quality-control charts (Fig. 3).

The components of each repeater are assembled into 17 related groups, as shown in Fig. 4, each within a small plastic cylinder coupled to its neighbour mechanically by helical springs and electrically by bus tapes; the whole assembly (Fig. 5) is then surrounded in turn by a double layer of steel rings and a copper jacket, before being completed into a cable-like structure with armour wires and servings. In this stage the repeater is nearly 8 ft long, but it is about twice the diameter of the cable itself; taper joints and tails, each some 30 ft long, are provided



4 *Block diagram of American repeater*

1. Input terminal.
2. Input blocking capacitor.
3. Earthing capacitor.
4. Crystal.
5. Input network.
6. Valve (first stage).
7. First inter-stage network.
8. Valve (second stage).
9. Second inter-stage network.
10. Valve (third st..ge).
11. Output network.
12. Beta network 1.
13. Beta network 2.
14. Gas-filled valve.
15. Drier.
16. Output blocking capacitor.
17. Output terminal.

at each end so that the whole will run smoothly through the laying machinery on the cable ship. Some details of the construction are shown in Fig. 6.

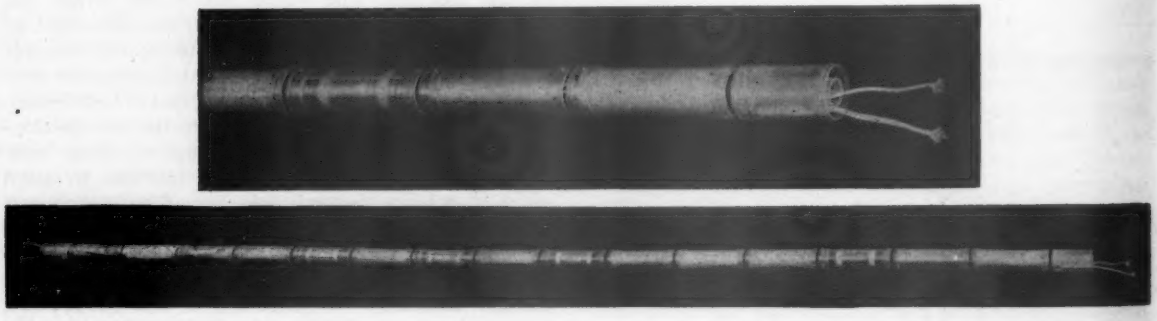
Looking rather like small torpedoes, some 9 ft long and 10½ inches in diameter, the repeaters for the Newfoundland–Nova Scotia link are a British development. The design basis is essentially different from the American, for these are two-way units for a single cable, having both 'go' and 'return' paths in the same housing. Moreover, although the design and production techniques were based on the objective of 20 years' trouble-free life, the circuits are so arranged that almost any single component can fail without putting the repeater out of service. Thus it was possible to use valves of more modern design, whose integrity had not been subject to rigorous trials over quite as many years as those for the longer section, where the failure of any one of some 6000 components could shut down the cable completely.

The electrical equipment of each repeater is contained in a hermetically sealed brass cylinder (filled with dry nitrogen) 50 inches long and 7¾ inches in diameter, the various units being mounted in a framework of plastic bars [Fig. 7(*a*)]; a flexible coaxial cable emerges through a seal in each end, ultimately to be jointed to the cable glands. As with the flexible repeaters, all the components are manufactured and assembled in an air-conditioned factory, under conditions of scrupulous cleanliness and rigorous inspection. The complete repeater is then sealed into a drawn-steel tube closed at the ends by steel bulkheads [Fig. 7(*b*)] carrying the cable glands through which the connections are made to the electrical unit, so that, although for the transatlantic link these repeaters will be used in comparatively shallow water, they are fully able to withstand laying in the deepest part of the ocean.

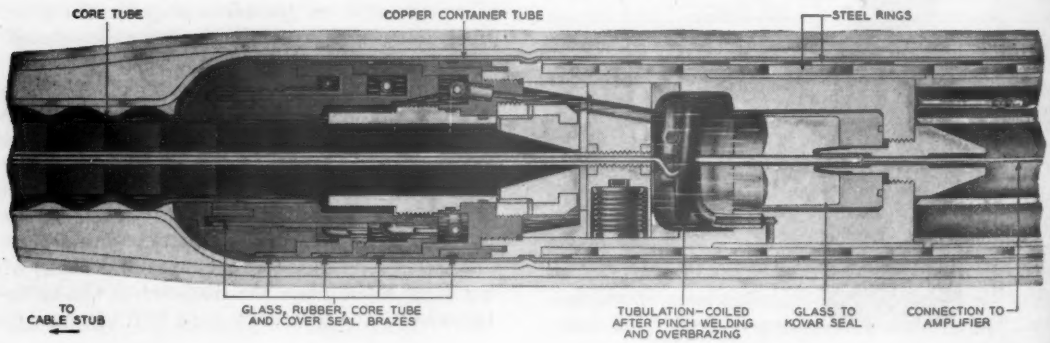
The Terminal Stations

The terminal stations posed a number of new, as well as all the old, problems. The decision to run the main transoceanic link clear to the north of the existing telegraph cables meant finding a Scottish site at the eastern end, but this was complicated by fast tides and

5 *The American repeater unit*



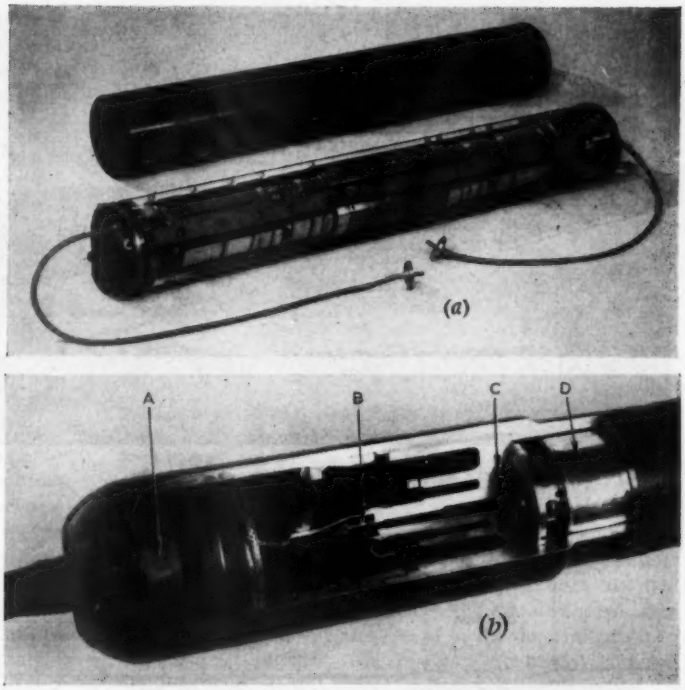
6 *Sectional view of seal assembly at each end of the American repeater*



rocky bottoms. Moreover, the site needs to be accessible for construction and maintenance, and capable of easy connection to trunk networks, for onward routing. In the outcome the cable was routed through the Firth of Lorne to Port Lathaich, a quiet bay some 3 miles from the busy port of Oban.

Conditions at the western landing offer even less choice. Newfoundland is a rugged, sparsely populated country with an inhospitable coastline, and surveys showed very little alternative to following the telegraph cables into Trinity Bay. With six telegraph cables terminating at Heart's Content on the southern shore, a landing on the north shore was desirable; and in view of the older problems of amenities and connection, the choice ultimately fell on Clarenville, a railway junction of some 1 600 inhabitants at the head of the north-west arm of Random Sound.

In both terminal stations much of the equipment follows standard trunk-telephone practice, or comprises either slight modifications to, or combinations of, standard equipment of proven integrity. However, in view of the tremendous length of cable involved, some special equipment is necessary to provide for the unusual power requirements and the unusually difficult conditions of fault location; once again, most of the test equipment is standard. Clarenville, of course, is not a true terminal station in the accepted sense, but is rather a junction between the long haul across the Atlantic itself and the shorter link across Cabot Strait to the mainland trunk routes.



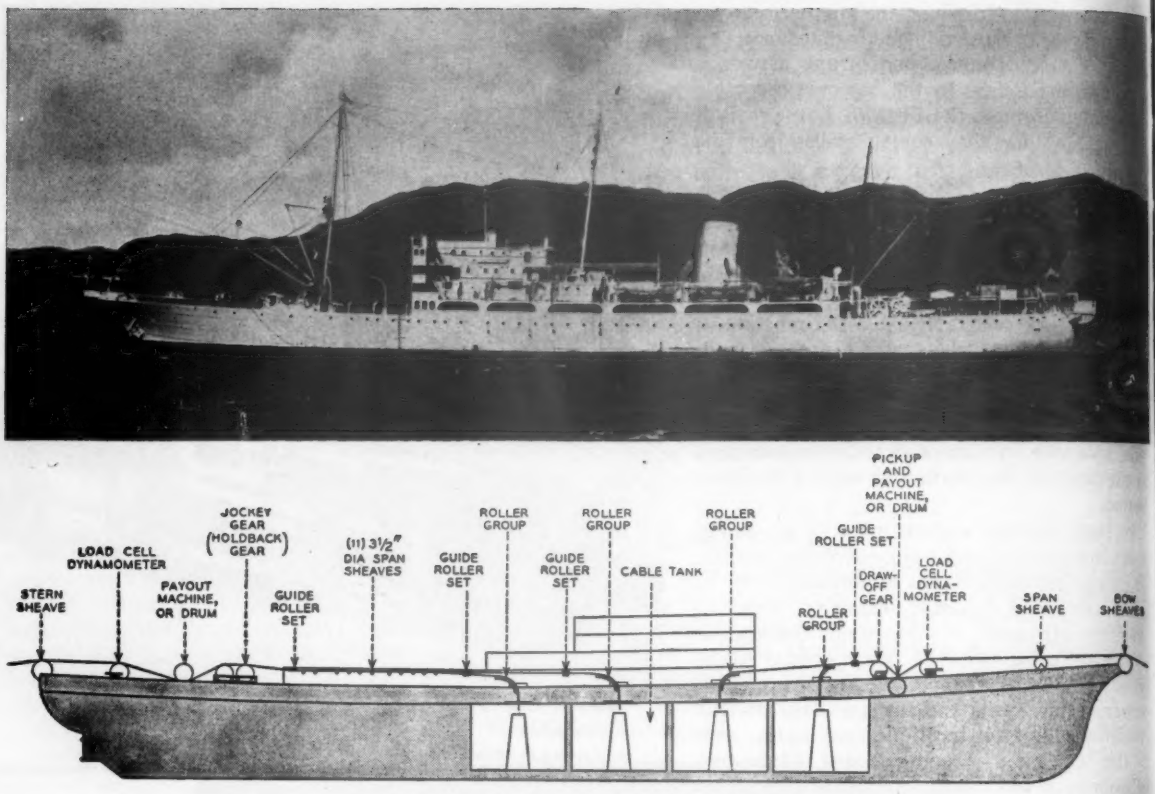
7 *Details of the British repeater*
a Internal unit.
b Housing construction.
A. Armour clamp. B. Gland. C. Bulkhead. D. Part of internal unit.

Laying the Cable

The ship selected to lay the cable—indeed, possibly the only ship in the world capable of doing so—was H.M.T.S. *Monarch* (Fig. 8), an 8 000-ton twin-screw vessel built in 1946 for the British Post Office, with an expert crew who had already laid and recovered telegraph cables in most of the waters of the world.

Ideally, the cable would be laid in a single passage from terminal to terminal, but even the *Monarch* could not carry enough cable. Thus the laying was accomplished in three sections—Clarenville to the mouth of Trinity Bay, from there to Rockall Bank, and from Rockall to Oban. *Monarch* commenced laying at Clarenville on the 20th June 1955, and brought the southernmost cable ashore at Oban on the 26th September while the east–west cable left Oban on the 6th June 1956, and was landed in Clarenville on the 14th August. Constant communication over the cable was maintained with the terminal station, except when splices were being made, and this facilitated the measurements required to determine the compensation for losses necessary at the end of each 'ocean block' of 150–200 miles.

But if the laying of the two deep-water cables called for navigation and seamanship of a supremely high order, it was no little of the spirit of the pioneer which carried the link onward to the North American continent. For the first 55 miles the single-cable link with its half-ton repeaters carved its way across the rocky undeveloped hinterland of Newfoundland (Fig. 9), following so far as possible the unstable dirt-tracks which pass for roads in the backwoods. Some relief was granted by the decision to lay the cable in some of the island's 'ponds' (stretches of water 3–4 miles long), across Random Sound itself and for some six miles along the bed of the Pipers Hole River. Even so, there can be little doubt of the relief and satisfaction felt by all concerned when the cable finally reached the terminal hut in the little port of Terrenceville, at the head of Fortune Bay; ahead now lay the shining waters of Cabot Strait, dangerous enough in all conscience but a straightforward lay from the *Monarch*. And indeed, despite heavy snow squalls in Fortune Bay and the additional problems of laying the rigid repeaters (a job which in bad weather calls forth the utmost from those making the joints on rolling decks), the cable was laid without incident, the final splice to the shore end at Sydney Mines, Nova Scotia, being completed on the 9th May. On that momentous day, in those remote Canadian waters, one-way telephone



8 *H.M.T.S. 'Monarch' and her cable gear*

communication across the Atlantic became possible. All that remained was the second deep-water cable, streaming astern of the *Monarch* as she steamed westward from Oban across the summer Atlantic. On the 14th August 1956 the final splice splashed into Random Sound and the link was complete—the transatlantic telephone had become a reality.

The Cable in Service

Despite the continuous testing which was a feature of the laying programme, much remained to be done before the new link could be handed over to the operators; thus it was not until the 25th September that an operator in the International Exchange in London connected the first British and American subscribers over the telephone cable. Public reaction was immediate, for on the following day all 36 channels were fully occupied during the peak period from 2 p.m. to 5 p.m. G.M.T., with 330 outgoing and 254 incoming calls during the day; four months later, on the 24th January 1957, a typical working day, the cable handled 333 outgoing, and 259 incoming calls. Delay working during the peak period became a feature of the service almost immediately it opened, thus indicating the extent of the demand. It is indeed instructive to examine the graphs showing the number of circuits occupied plotted against time of day. Day after day the heavy demand during the hours when office work in London and New York overlaps occurs with almost clockwork precision, followed by a sharp fall at tea-time and another swift rise through the 'cheap-rate' period, reaching a peak at about 9 p.m. in England.

Instructive, too, are the minor misjudgments made by the planners, for they reveal interesting sidelights on the public character—though of insignificance in the overall success of the scheme. For instance, in view of the greater ease of conversation which the cable offers in comparison with the radiotelephone, it was believed that the public, buying time at £1 a minute, would be glad to shorten their calls; but experience since the link was opened shows that the average duration has increased. Again, although the Canadian allocation of only 6½ of the 36 channels is justified by the number of calls going from London to Montreal, in the reverse direction there are three times as many calls, many of them rerouted to Europe. The resulting demand in Canada has indeed exceeded all possible expectations.

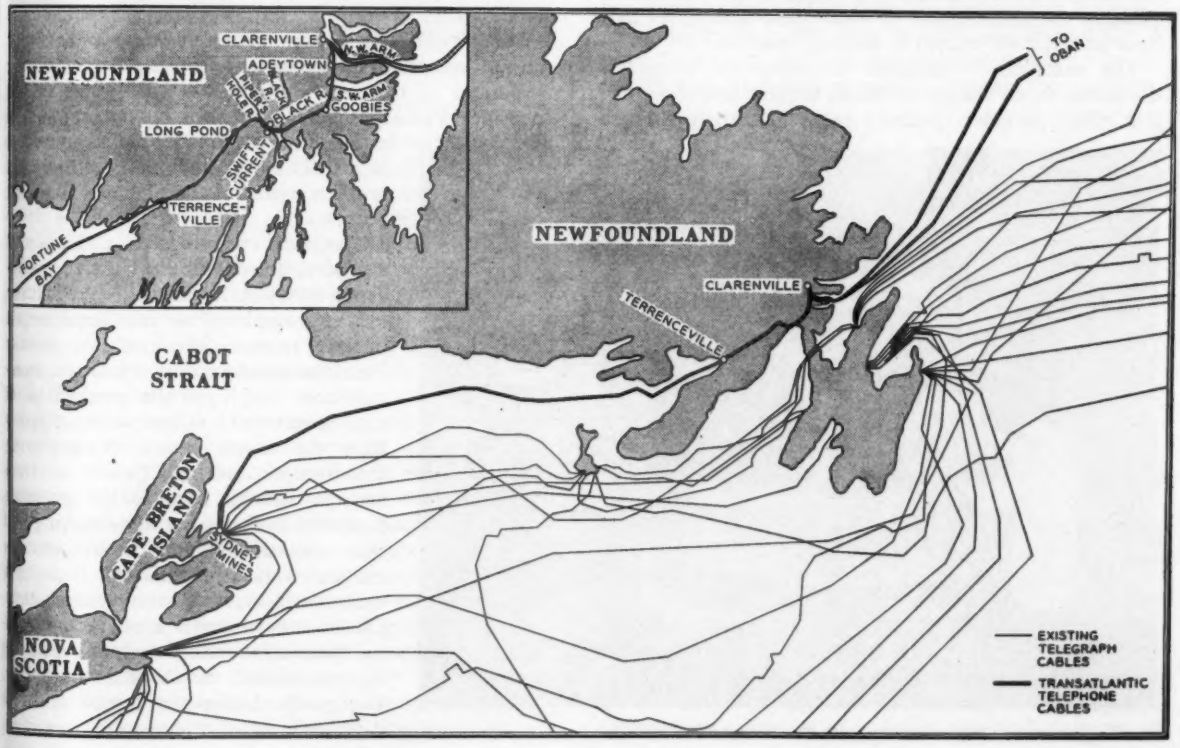
And as the telegraph cables continued to find work after the radiotelephone had proved itself, so the best of the radio circuits continue in service; indeed, the subscriber who initiates a transatlantic call cannot be certain whether he will get a radio or a cable connection, for the

operators make the choice on a purely random basis; true, some subscribers are reluctant to accept a radio connection, although the radio service is used only at its highest standards of quality. Apart from providing additional circuits, the radiotelephone provides a line of defence against cable failure, so that it is vital that the service should not lapse; if it did, the Post Office might well find that the unused frequencies would rapidly be annexed by one or other of the many broadcasting or communication services in Europe fighting for a place in the overcrowded ether. The importance of this alternative service has already been demonstrated when the radio link across Nova Scotia failed for a brief period in January and the radiotelephone resumed the entire service. The fault occurred in wild trackless country blanketed by four feet of snow: the story of the engineer who risked his life from a helicopter to bring the link back to life hours before the snow tractors could get through is one of those little sagas of the telephone and telegraph services which seldom, if ever, get beyond a laconic note in the routine servicing diary.

So the cable is in service, and working successfully; and it is fair to speculate on what comes next, for the one certainty is that neither country will stop here. On the western seaboard there is much to suggest an offshore link between the United States and Latin America, while the vast Pacific depths between San Francisco and Honolulu will certainly yield within a year. (*Monarch* left England with the first cargo of cable for this connection in May 1957.) In Britain the obvious choice is a Commonwealth link to Ascension Island or Capetown, so that the radiotelephone bandwidth available in the southern hemisphere could be greatly increased by sharing the North-Atlantic frequencies. Statistics, however, show that the demand for such a link is barely half that of the transatlantic link. But then statistics suggested that the transatlantic cable would reach saturation in 1965, not 1957, and already plans have been announced to lay more cables to North America. One of these—due for completion in 1959—will again use the American twin-cable system to connect the United States and Canada with France and Germany, while the other—a British venture scheduled for 1961—will use rigid repeaters and a new, lightweight, two-way cable.

Yet in the midst of speculation on the advances in technology which the future holds, and with no little admiration of what has already been accomplished, let us not forget the human factor. For without the tremendous enthusiasm of every man and woman involved, backed by international co-operation to a degree almost unique in history, this project would have been doomed to fail. When petty prejudice, personal desires and national pride can be subjugated to the determination to achieve near-perfection in this way, no heights are too high, no obstacle too great. Is there not here a lesson for all of us?

9 *Cable landings on Newfoundland, and the final route of the overhead section of the Clarenville–Sydney Mines cable*



A REVIEW *of the Proceedings, Parts A and B*

SHORT REVIEWS OF PAPERS

On the following pages are some brief articles based on, and written by the authors of, current Institution papers. The authors have been asked to make these articles, so far as possible, of appeal to electrical engineers who have no specialized knowledge of the subjects, and the content of the articles is not necessarily confined to the subject-matter of the original papers.

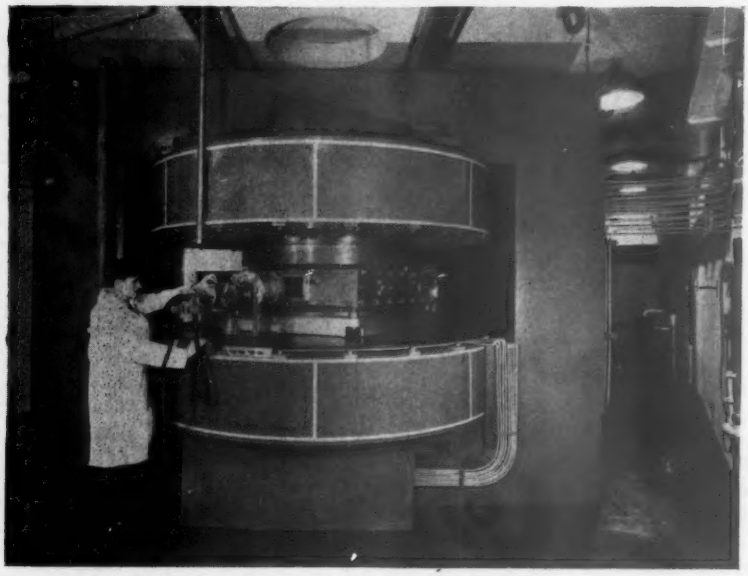
Medical Cyclotron

A short review of a Measurement and Control Section paper (No. 2342) entitled 'A Cyclotron for Medical Research', by J. W. Gallop, B.Sc.(Eng.), Member, D. D. Vonberg, B.Sc.(Eng.), Associate Member, R. J. Post, Associate Member, W. B. Powell, M.A., Graduate, J. Sharp, B.Sc.(Eng.), Associate Member, and P. J. Waterton, B.Sc.(Eng.), Associate Member. The paper was published individually in March 1957, and it will be republished in Part B of the Proceedings. The authors are with the Medical Research Council.

THE MEDICAL RESEARCH COUNCIL'S CYCLOTRON AT Hammersmith Hospital is the first such machine to be placed within the precincts of a hospital, where it renders possible the development of many new techniques that have hitherto not existed in medical research.

The machine is designed to accelerate beams of deuterons to an energy of fifteen million electron-volts, and alpha particles to about twice that energy. These charged particles may either be used directly or made to bombard suitable targets in order to produce radioactive isotopes or beams of neutrons. Large fluxes of neutrons are produced when a deuteron beam strikes a beryllium target, and these particles, because they are uncharged, have powers of penetration very similar to X-rays and thus offer possibilities of extending the field of radiation therapy. This will not be the first time that such possibilities have been investigated. Between 1938 and 1942 a series of trials were made using the Crocker Radiation Laboratory's 60-inch cyclotron at the University of California. The results were somewhat discouraging, but it is felt that they were not sufficiently conclusive to destroy all hope that such treatment might prove successful when more is known about the biological effects of neutron radiation.

Neutrons produce their biological effects through the intermediary of recoil protons which ionize the material through which they are passing. Owing to the wide energy spectrum of the recoil protons, the ionization produced in this way comprises a wide range of ion densities. For experiments, therefore, in which biological or chemical response is being measured as a function of ion density, direct use is often made of the alpha or deuteron beams.



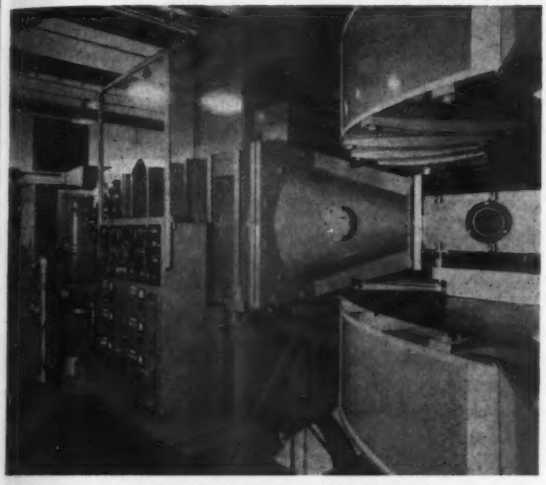
1 *Cyclotron, showing electromagnet and vacuum box*

The most versatile in application of all the cyclotron products are the radioactive isotopes. In this field the cyclotron may be regarded as complementing a nuclear reactor. Most of the nuclear reactions produced by cyclotron bombardment result in the production of an isotope which is chemically different from the target material. Thus carrier-free isotopes and high specific activities become available. Many of the cyclotron-produced isotopes are fast-decaying and thus present obvious advantages for medical work since one can be sure of their harmlessness in a very short time. On the other hand it is obviously essential that the source of such fast-decaying isotopes should be as near the patient as possible. Isotopes are used both for diagnostic and therapeutic purposes,

and though much has already been done in these fields the presence of a source of cyclotron-produced isotopes in a hospital will add greatly to the range available to medical workers.

The pole diameter of the magnet is a rough measure of possible output, and cyclotrons are usually classified in this way. On this basis the Hammersmith cyclotron is a 50-inch machine. Fig. 1 shows the electromagnet, between the two coils of which is the vacuum box containing the accelerating electrodes. The ion-source gate valve is attached.

Fig. 2 shows a view of the vacuum vessel. A small portion of the vacuum box can be seen on the right,



2 *Vacuum vessel and local vacuum control panel*

between the magnet poles, connected through a taper section to the parallel section. These, with the vacuum 'take-off' box at the rear, comprise the vacuum envelope, which is evacuated by two 16-inch oil diffusion pumps. One of these pumps can be seen connected to the vacuum 'take-off' box immediately behind the vacuum control panel. The r.f. power amplifier, from which the accelerating voltage is derived, can be seen on top of the parallel section. The whole machine is enclosed in a concrete room, whose 6 ft thick walls and ceiling form a biological shield against radiation.

Emphasis throughout the design has been upon ease of maintenance and rapid automatic isolation and location of faults. In many cases, where interlocks are necessary to ensure a correct sequence of operations, little more is involved in making these completely automatic. This has been done where operations involve a number of waiting periods—such as vacuum pump-down and the starting up of the complete machine, which has been reduced to the operation of three gang controls. Provision has, of course, been made to carry out these operations by hand if so desired.

The cyclotron first became operational when switched on from the control room by Her Majesty the Queen in June 1955 (Fig. 3). Since that time work has been concentrated on measurements concerned with internal beam dynamics and preliminary neutron measurements from an internal target. The importance of beam dynamics lies in the fact that by stabilizing the beam

3 *H.M. the Queen switching on the cyclotron for the first time from the control room, June 1955*

position in the machine and by stopping off, early in the cycle, that portion of the beam which would ultimately be lost to the electrode system, heating of the electrodes is reduced and the limit of the available output is raised. In addition, since the stray beam is responsible for a large fraction of the radioactivity that builds up inside the machine, its reduction eases the maintenance problem.

621.384.611:573.534

Analogue Computers in Nuclear Power

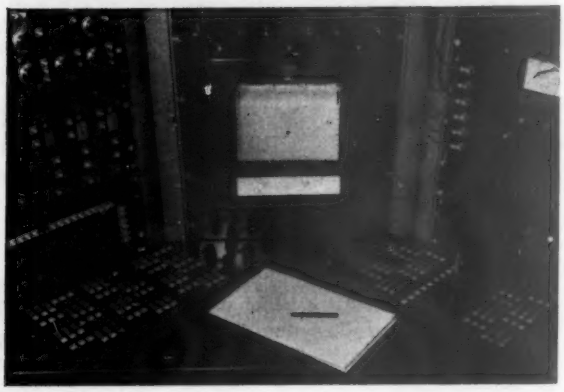
A short review of two Measurement and Control Section papers (Nos. 2337 and 2338) entitled 'An Analogue Computer for Nuclear Power Studies' and 'The Application of Analogue Methods to Compute and Predict Xenon Poisoning in a High-Flux Nuclear Reactor', by G. J. R. MacLusky, B.Sc. The papers were published individually in March 1957, and they will be republished in Part B of the Proceedings. The author is at the Atomic Energy Research Establishment.

IN RECENT YEARS THERE HAVE BEEN MANY APPLICATIONS of electronic analogue computers to the solution of problems involving complex feedback systems, such as the transient behaviour of an aircraft and its automatic pilot, or the simulation of a guided missile and its complete guidance system.

Such analogue computers can be seen as a development of the earlier electromechanical differential analysers, solving differential equations in essentially the same

manner but with the mechanical integrators replaced by d.c. amplifiers with resistive input and capacitative feedback. However, they can equally well be regarded as scale working models of the systems being studied, where the mechanical or other interactions between different parts of the system are matched by analogous interconnections between different electronic amplifiers, and the scale factors are chosen to relate voltages or currents at various points in the computer to the corresponding variables in the original system.

A new analogue computer has been built at the Atomic Energy Research Establishment to be used in investigations of the kinetic behaviour of projected nuclear reactors and their associated power systems. In general it deals only with the variation with time of the relevant quantities, e.g. neutron flux, uranium temperature and coolant outlet temperature. Where there are, in addition, spatial variations in the quantities concerned, the computer is set up to represent appropriate averaged values. With some quantities, such as heat-exchanger temperatures or axial temperature variations along a fuel channel, it is possible to approximate to spatial variations by dividing the structure into a number of zones and considering the quantity concerned as averaged separately over each zone.



Control desk

The desk carries sockets connected to the amplifier outputs and coefficient unit inputs, arranged in a pattern corresponding to the layout of these units in the computer. By means of short wander leads, the initial-condition potentiometers can be connected to the chosen coefficient units, and the inputs for the two 3-channel recorders (of which only the lower appears on the photograph) can be connected to the required amplifier outputs. On the left of the photograph are the eleven keys required for reading and resetting in the reactor-kinetics section, and below them the corresponding keys controlling the whole computer.

Forty vibrator-stabilized d.c. amplifiers are available, and, in the sections of the computer which deal with the control and thermal systems of the reactor, these can be interconnected in any required way by means of resistance and capacitance coefficient units. This flexibility is necessary to allow for the very wide variation in possible thermal and control systems.

However, the same basic equations can be used to describe, for different reactors, the way in which the total neutron population builds up or decays in responses to variation in the reactivity of the system. The differences between reactors concern only the parameters in the equations (e.g. neutron mean lifetime, abundances of different groups of delayed neutrons) and consequently a fixed circuit arrangement is used in the reactor-kinetics section of the computer, with appropriate controls for the parameters which must be varied. It is shown that provided the neutron multiplication factor K is near to unity the original system of non-linear differential equations can be reduced to twelve linear equations and only one non-linear equation, allowing a relatively simple analogue to be employed. The remaining non-linearity arises from the requirement that the rate of change of neutron population shall be proportional to the product of existing neutron population and reactivity $(K-1)$, and a servo-type multiplier is used for this purpose.

The various quantities which determine net reactivity (e.g. control-rod position, fuel temperature) appear as voltages at various points in the computer, and their sum gives the input to the servo multiplier.

The author concludes his first paper with a description of the method employed to compensate for the finite frequency response of the reactivity servo multiplier, and mentions some of the problems to be studied with this new computer, a view of which appears in the photograph.

The second paper describes an analogue computer to be used during the operation of a reactor, rather than in the preliminary design studies. It is designed to compute the reduction of the reactivity of the reactor due to the accumulation within it of xenon 135, a fission product which has an extremely large capture cross-section for neutrons. This isotope which is radioactive, with a half life of 9·2 hours, is produced partly by the fission of uranium 235 but primarily by the decay of iodine 135 (6·7 hours half life) which is itself a direct fission product. After a reactor has been operating at a steady power for many hours an equilibrium is reached, with the rate of production of xenon 135 balanced by its total rate of destruction due to radioactive decay and to neutron capture, which converts it into xenon 136. If the reactor power is then reduced, there will be a proportionate decrease in the rate of destruction of xenon 135 by neutron capture, but its production from the decay of iodine 135 will continue, and there will be a rapid increase in the xenon concentration. In reactors which operate at a high neutron flux there may be so great an increase in neutron absorption that, even with all other absorbers removed, the neutron reproduction factor K falls below unity, and it is not possible to operate the reactor again until the xenon has decayed to a sufficiently low concentration, which may be up to 40 hours later.

It may be possible to avoid such unfortunate results if the reactor operators are given a computed value of the xenon 'poisoning', derived from an analogue solution of the relevant equations.

Two d.c. amplifiers are used in the computer, their output voltages being proportional to the concentrations

of iodine and xenon. The required feedback time-constants are 9·6 and 13·2 hours and are obtained from 4μF polystyrene-film capacitors in parallel with glass-sealed resistors of about $10^{10}\Omega$. The computer operates continuously, being supplied with the required information on the reactor power by means of a three-gang potentiometer driven from a power recorder.

Associated with the computer is a predictor on which an assumed future power can be set. Its general arrangement is the same as the computer section, from which it takes its initial values of iodine and xenon concentrations, but its time-constants are reduced by a factor switched to either 1/60 or 1/3 600, so that it predicts the future course of xenon poisoning on a seconds-to-minutes or seconds-to-hours time scale. By this means the reactor operators can visualize the future changes in xenon poisoning which would follow some change in reactor power, and possibly make preparations to overcome it.

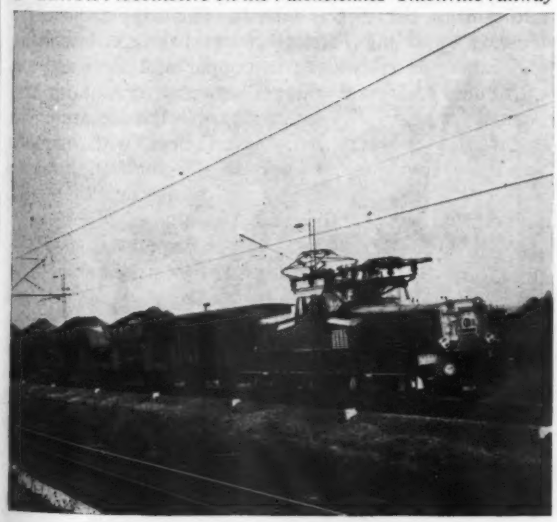
621.317.79: 681.142: 539.712.4

Rectifier Locomotives

A short review of a Utilization Section paper (No. 2339) entitled 'Electrical Equipment for Rectifier Locomotives', by H. B. Calverley, B.Sc.(Eng.), Associate Member, E. A. K. Jarvis, B.Sc., Associate Member, and E. Williams, B.Sc.(Eng.), Associate Member. The paper was published individually in March 1957, and it will be republished in Part A of the Proceedings. The authors are with the English Electric Co.

SINCE THE WAR A VERITABLE REVOLUTION HAS TAKEN place in electric-traction techniques owing to the use of industrial-frequency current to supply power to trains.

1 *S.N.C.F. locomotive on the Valenciennes–Thionville railway*



The possibilities of the 50 c/s system had been foreseen by many, but it was the engineers of the French National Railways who tackled in a determined way the problems posed by the use of this system and applied it on a large scale to the Valenciennes–Thionville railway in 1954 (Fig. 1).

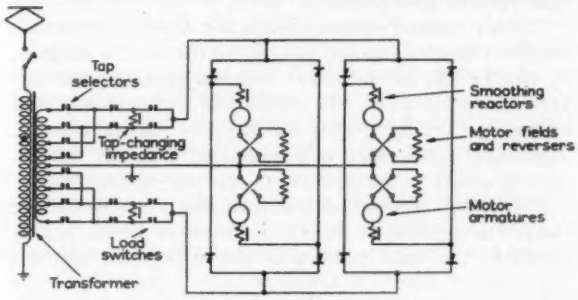
The principal advantages of the system are:

(*a*) Economy due to wide spacing of substations and light overhead-wire construction, resulting from the use of a high voltage (25 kV) to distribute power to the trains.

(*b*) Simplicity of substations, which contain only outdoor switchgear and transformers.

(*c*) Practicability of using several widely different types of locomotive equipment, each type presenting some useful features.

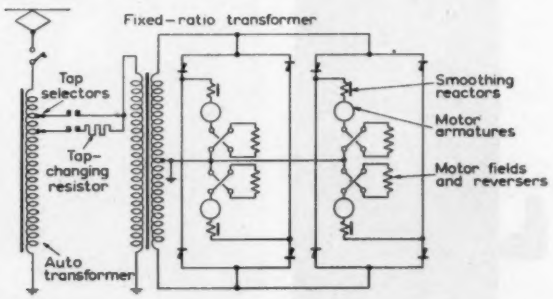
Equipments of the rectifier type are becoming more and more widely favoured, and the paper deals only with this type. British Railways have adopted the 50 c/s system and will be using rectifier motor-coaches and locomotives.



2 *Low-voltage tap-changing equipment*

The strongest argument against rectifier equipment has been the fear of troubles in the power system and in communication systems owing to the harmonic currents generated by the equipments. However, if the traction supply is from a high-power network, the first fear is apparently groundless, and the communication-interference problem is solved by cabling the communication circuits—often an economically justified procedure even without electrification.

The two circuit diagrams show the major items of equipment and their interconnection. Figs. 2 and 3



3 *High-voltage tap-changing equipment*

illustrate l.v. and h.v. tap-changing respectively. The power is controlled by adjusting the voltage applied to the rectifiers by means of the on-load tap-changing equipment. The adjustment is from zero to full output voltage in forty or more steps, and this must occur without even a momentary interruption of the current.

For l.v. control, the tap-changing equipment selects the appropriate tapping on the transformer secondary winding, and transitions may be effected by the well-known mid-point auto-transformer scheme, which gives an additional notch midway between tappings. Alternatively a simple impedance may be used for transition, and a pseudo mid-notch may be obtained by using the impedance in series with the load.

In the h.v. method of control the tap-changing equipment selects tappings on an auto-transformer, which is supplied from the overhead line at 25 kV. The output of the tap-changer feeds the primary winding of the fixed-ratio rectifier transformer.

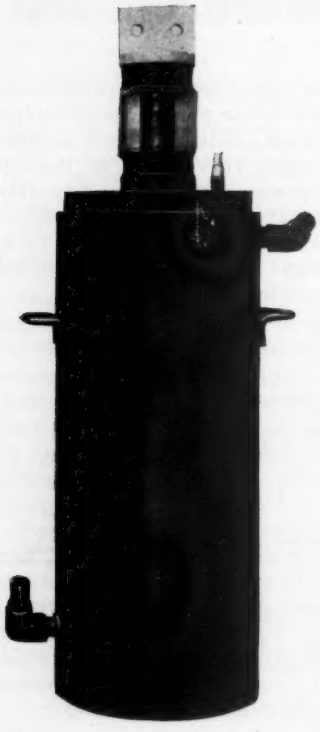
The h.v. control scheme results in a tap-changer which handles currents smaller than those for the l.v. scheme. It usually has oil-immersed selector contacts and air-break load switches, all interlocked mechanically and operated either by electric motor or by manual control. The total transformer size is greater than for the l.v. scheme owing to the addition of the auto-transformer.

For either method of control, the variable-voltage output is applied to banks of rectifiers which supply power to the traction motors. Hence, to each motor a direct voltage is applied, which is increased in steps as desired. Motors are thus not connected in series at starting, and no starting resistors are used; therefore the motor voltage is stabilized. This results in better adhesion between wheel and rail than is obtained with d.c. locomotives, because if a wheel should start to slip a small rise in speed will cause a large drop in torque and the wheel will more readily regain adhesion.

The locomotive power is controlled mainly by the on-load tap-changer, although often some traction-motor field weakening is used on the top tapping in order to obtain greater power at high speeds.

The main transformer is the largest single item of equipment—weighing up to 8 tons or more. It is single phase, is often of the shell-type construction and is usually oil-immersed, with forced oil circulation (by external pump) and air-blast cooling. Since a high rated-output/weight ratio is necessary, grain-oriented cold-rolled iron is used (which can be worked at high flux density) and the current density in the copper is high. Oil velocities are high, in order to obtain good heat transfer.

Mercury-arc rectifiers have been used exclusively to date, the great majority being water-cooled ignitrons, Fig. 4. Two rectifiers deliver a mean current of, say, 800 amp at 800 volts to one traction motor. By winding the motors for as high a voltage as possible, a given rectifier can be made to operate with greater efficiency and to give a higher rated power output. It is an advantage to connect the rectifiers in a bridge circuit because this reduces the size of transformer needed.



4 *Water-cooled ignitron rectifier*

The new semi-conductor rectifiers are very attractive for locomotives since they require very little auxiliary equipment. Silicon rectifiers in particular would be considerably smaller than the mercury-arc equipment. However, at present these new rectifiers are considerably more expensive than the mercury-arc type.

The traction motors operate under some difficulties owing to their having to carry a large ripple current in addition to the direct current. This ripple current is reduced by adding a series reactor in the d.c. circuit but still causes extra heating in copper and iron and also introduces additional voltages between commutator bars. A small transformer e.m.f. appears in the armature coils undergoing commutation. Nevertheless, with attention to a few points in design, a practically standard d.c. series motor works quite well in spite of the ripple current, although a small derating may be necessary.

With regard to future developments, it seems highly probable that silicon rectifiers will be used before long, with considerable reduction in size and weight, and greater simplicity. The tap-changing schemes at present used are inclined to be somewhat crude, since they produce sudden changes in output voltage and entail considerable circulating current during transition. The authors suggest that an infinitely variable system of control should be devised.

The rectifier locomotive combines the lightest convertor with the best possible traction motor, and allows

voltage control of the motors to be used, resulting in remarkably good adhesion. It surely has a great future.

621.337.1

Electric Traction Calculations

A short review of a Utilization Section paper (No. 2340) entitled 'Circuit Calculations for Rectifier Locomotives and Motor-Coaches', by T. E. Calverley, B.Sc.(Eng.), Associate Member, and D. G. Taylor, B.Sc.(Eng.), Graduate. The paper was published individually in March 1957, and it will be republished in Part A of the Proceedings. The authors are with the English Electric Co.

THE INCREASING USE OF RECTIFIER LOCOMOTIVES AND motor-coaches has revealed the limitations of the established circuit theory of multi-phase rectifiers when applied to bi-phase and single-phase/bridge-connected rectifier circuits. The established theory is based on the assumption that the direct load-circuit current is smoothed perfectly by an infinitely large inductance. This assumption leads to considerable simplification of the theory which is adequate for most problems involving installations having six- (or some multiple of six-) phase output. In typical bi-phase or single-phase bridge circuits, however, the undulations in the output current are sufficiently great to invalidate the accepted theory.

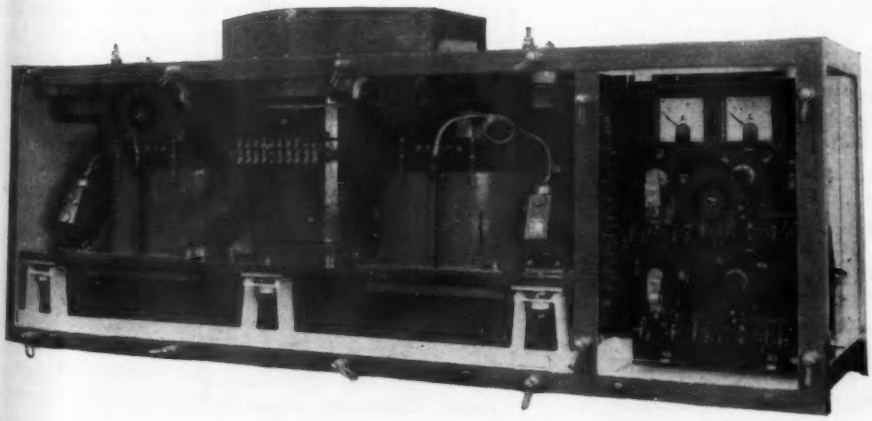
The authors show the extent to which the established theory is at variance with operational experience by comparing the results of tests on the Lancaster–Morecambe–Heysham section of British Railways with calculations based on the established theory. Appreciable discrepancies are found in such important features of performance as the harmonic currents fed into the supply system, the power factor ($\cos \phi$) at the substation and pantograph, and the percentage harmonic currents in the traction motors. In all three instances, the values calculated by the established 'infinite inductance' theory are higher than the measured values.

In view of the above discrepancies, it is surprising to find, to date, that the direct voltage measured at the motors has been found to be very close to that calculated by the established 'infinite inductance' theory.

The shortcomings of the accepted theory indicated that a more comprehensive approach to single-phase rectifier problems was needed if power factor and line-current harmonics were to be predicted with sufficient accuracy. The authors give a description of a new approach to rectifier problems, by means of which solutions to both transient and steady-state problems can be obtained, taking proper account of resistances, inductances and capacitances in all parts of the circuits. The problems are treated as circuit problems, the equilibrium equations being established in terms of mesh currents and expressed as simultaneous first-order differential equations. These are solved by the digital computer Deuce, whose logical facilities are used to take account of the valve action of the rectifying elements. The results of calculations are compared with test results, the correspondence being good. The authors describe the way in which the various components of a traction system are represented in the analysis. Preliminary calculations revealed that it is essential to take proper account of resistances everywhere in the circuit in order to predict power factors with sufficient accuracy; capacitances have been neglected in the paper in the interests of simplicity.

The authors describe examples based on a tentative design for a 3000 h.p. locomotive, indicating how the facilities provided by the digital computer programme can be used to assess the effects of design modifications. The probable effects of capacitance are discussed, with particular reference to systems operating at higher voltages on the a.c. side than that used on the Lancaster–Morecambe–Heysham section of British Railways. A more comprehensive digital computer programme is being made which will include facilities for taking account of capacitances, and of supply and load circuits of any configuration, with a limit on the total number of meshes in the circuits.

The value of the computing facility is illustrated in the paper by a table comparing the results of calculations for the 3000 h.p. locomotive for various values of the d.c.



1 *Rectifier assembly for under-car mounting on a motor-coach*

reactor inductance, all other parameters being kept constant. The optimum value of the inductance can then be chosen to give the best operational performance within the limitations of many conflicting requirements.

A mercury-arc-rectifier assembly suitable for under-car mounting is shown in Fig. 1. The excitron-type rectifiers shown have been in operational service on the Lancaster–Morcambe–Heysham system for the last two years. Each three-car train requires two pairs of excitrons. Fig. 2 shows a picture of a typical excitron removed from its container.

621.335.2 : 621.335.42

2 *Typical air-cooled excitron*

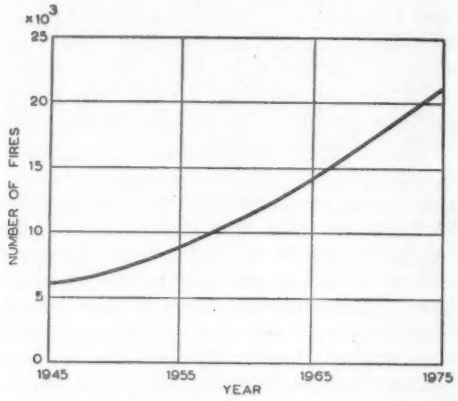
Fires of Electrical Origin

A short review of a Utilization Section paper (No. 2316) with the above title, by D. I. Lawson, M.Sc., F.Inst.P., Member, and J. F. Fry, B.Sc., A.M.I.C.E. The paper was published in April 1957 in Part A of the Proceedings. The authors are with the Joint Fire Research Organization of the Department of Scientific and Industrial Research and the Fire Offices Committee.

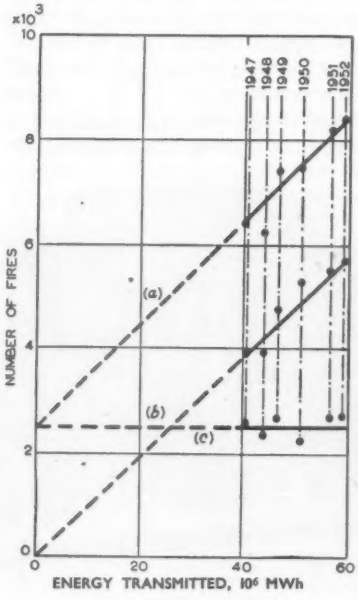
FROM PUBLISHED STATISTICS OF FIRES AND ESTIMATES OF the probable growth in the use of electricity it is calculated that by 1975, in the absence of effective preventive measures, fire brigades in Great Britain will be called annually to some 22 000 fires associated with the use of electricity (Fig. 1). The number of such calls in 1955 was about 9 800, having risen from 6 500 in 1947. The incidence of these fires appears to be proportional to the amount of electrical energy transmitted, there being approximately one fire per 10^7 kWh (Fig. 2).

The number of fires due to fixed wire and cable does not appear to depend appreciably on the amount of energy transmitted, and the annual incidence has remained fairly constant for some years. It has, however, been shown by Gosland that installations become increasingly susceptible to fire with age, and this fact is likely to assume greater importance in the next twenty years. There is no evidence at present that the fires which occur in fixed wire and cable, about 2 500 each year, are due to overloading.

The increase in electrical fires has been chiefly attributed to the use of electrical apparatus. The expanding use of this equipment, domestically and industrially, means that this is the field in which the greatest contribution to the reduction of fire incidence can be made; but it will be necessary to collect information on the types of apparatus involved and on causes of fires. This is to be the subject of a special survey in which all fire brigades are being asked to assist.



1 *Estimated number of fires of electrical origin occurring annually in Great Britain for the period up to 1975*



2 *Number of fires of electrical origin occurring annually, in terms of electrical energy transmitted*

a Total fires of electrical origin.
b Fires due to electrical apparatus.
c Fires due to wire and cable.

An increase in fires of electrical origin may be accompanied by some decrease in the number associated with other fuels. For example, the substitution of electric heaters for solid-fuel appliances would result in an increase in the number of fires associated with electricity and a reduction in those associated with solid fuels. But this compensation cannot be complete, for some kinds of apparatus, such as radio and television sets, have no counterpart using other fuels. Moreover, some types of electrical equipment are more liable to cause fires than their equivalents using other fuels, independently of electrical faults. For example, it is perfectly safe to warm clothing on a hot-water radiator but it would not be safe to put the clothing on a tubular electric heater. There may be a case for the better education of the public, but efforts to make apparatus completely foolproof are likely to be more effective.

Suggestions for possible remedial measures will have to await the results of the survey previously mentioned.

621.3:614.84

T.V. Bandwidth Compression

A short review of a Radio and Telecommunication Section paper (No. 2357) entitled 'Bandwidth Compression of a Television Signal', by G. G. Gouriet, Associate Member. The paper was published in May 1957 in Part B of the Proceedings. The author is with the British Broadcasting Corporation.

PRESENT-DAY TELEVISION SIGNALS CONTAIN CONSIDERABLE redundancy in the 'information theory' sense, with the result that the bandwidth used is excessive. The paper considers a particular form of redundancy and possible means by which it could be eliminated to provide a substantial reduction of bandwidth.

The form of redundancy referred to may be termed *picture element* redundancy; it arises because in any normal picture there are plain areas over which the brightness is virtually constant. In such areas it is unnecessary to describe each picture element separately, and in fact two data will suffice, one giving the value of brightness, and the other the duration along the scanning line for which the brightness is maintained.

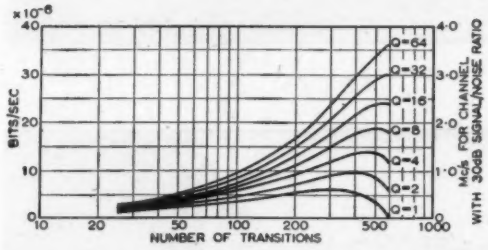
A definite meaning may be attached to *constant brightness* if the signal is quantized into a number of discrete levels; variations of smaller magnitude than one 'quantum' will not be reproduced and may therefore be regarded as constant by definition. By the use of straightforward techniques, it is possible, after sampling and quantizing, to produce two separate pulse trains, one of which describes the duration of each significant change of brightness, and the other the magnitude of the brightness after the change has occurred. The total information in these two signals may be deduced by using information theory, and is shown to be:

$$H_t = r \log_2 Q + (N-1)\log_2 (N-1) - r \log_2 r - (N-r-1)\log_2 (N-r-1)$$

where H_t = total information,
N = number of picture elements in a scanning line,
r = number of significant brightness changes,
and Q = number of brightness quanta.

This equation has been plotted as a family of curves, reproduced in Fig. 1.

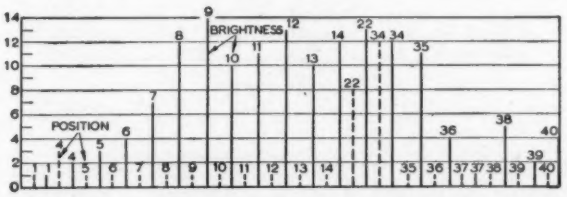
Experiments have indicated that the number of significant transitions per line, averaged over a complete picture, rarely exceeds fifty. On the basis of thirty-two brightness quanta, this will be seen from Fig. 1 to require



1 *Rate of information as a function of number of transitions and brightness quanta for 100 microsec scanning line containing 600 elements*

one-seventh of the present-day channel capacity, which caters for 600 picture elements per line.

In order to realize a saving in bandwidth, it is necessary to arrange that the pulses are spaced equally in time, in which case a bandwidth of W c/s can transmit $2W$ pulses. The author discusses means by which the pulses may be stored and redistributed to have constant time intervals, and Fig. 2 shows two such pulse trains interleaved to form a single signal.



2 *Position and brightness pulses interleaved to form single signal*

The receiver for such a system is fairly simple; the positions of all transitions are correctly located if the velocity of scan is made proportional to the magnitude of the position pulses. The brightness signal operates in the normal manner except that it is necessary to introduce compensation for the variations of brightness caused by changes in the scanning velocity. The effect of noise at

a

b

3 *Example of quantization*

a Scene reproduced by conventional 405-line system.
b Scene reproduced by 405-line system with 6-level brightness quantization.

the input of the receiver is discussed, and it is shown that, because the method of coding is not ideal, a high value of signal/noise ratio is required for the position signal.

A possible variation of the method is descibed in which fewer brightness quanta are used. On the basis of six brightness quanta, the number of significant brightness transitions in any scanning line would seldom exceed fifty, as opposed to an average of fifty taken over a complete picture. This reduces considerably the instrumental complexity, since storage and redistribution need be effected only over the period of a scanning line. An example of a television picture quantized into six levels is shown in Fig. 3.

621.397 : 621.391

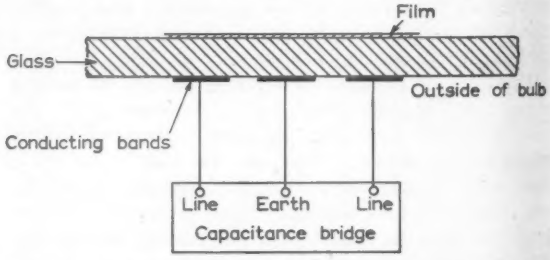
Detection of Films in Valves

A short review of a Radio and Telecommunication Section paper (No. 2335) entitled 'A New Method for the Detection of Thin Conducting Films in Thermionic Valves', by F. H. Reynolds, B.Sc.(Eng.), and M. W. Rogers. The paper was published in May 1957 in Part B of the Proceedings. The authors are at the Post Office Research Station.

IN RECENT YEARS, THE TWO PRINCIPAL CAUSES OF VALVE failure—loss of cathode emission and growth of cathode interface resistance—have been brought under control to such an extent that attention may now be focused on some of the other defects of the thermionic valve. These include the development of excessive noise and the growth of inter-electrode leakages and capacitances, both of which can be attributed to the deposition of thin conducting films on the insulating surfaces within the valve bulb. These defects can easily rank as causes of valve failure, particularly where an exacting life specification has to be satisfied. The triple-band method of film detection facilitates exploration of the movement of those materials within the bulb of a thermionic valve which give rise to such defects.

The triple-band method enables a film on an insulated surface to be detected without the need for making direct contact with the film. It is particularly suitable for detecting films on the inner wall of the bulb of a valve, and since no special valve constructions are necessary the method is readily applicable to valves destined for service. The method also allows the film density to be plotted over most of the surface of the bulb, thus enabling the sources of films to be identified.

The principle of the method is shown in Fig. 1. Three

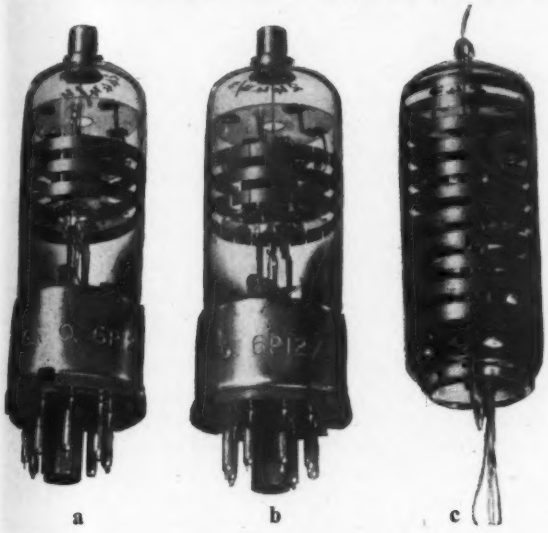


1 *Section through triple-band system and connections to bridge*

electrodes are formed on an insulator, on the opposite side to that on which the film may be deposited. The two outer electrodes, which are connected to the line terminals of a capacitance bridge, are normally screened from each other by the central, earthed electrode. As soon as a film is deposited in the position shown, the earthed band is effectively by-passed and the bridge records an increased capacitance. Analysis of the system

shows that the capacitance change can be used to find the conductivity of the film.

The electrode arrangement of Fig. 2*a* is suitable for the detection of a conducting film deposited on the inner wall of the bulb in the vicinity of the mount. By means of the arrangement of Fig. 2*b* the circumferential distribution of such a film can be determined. The electrodes of Fig. 2*c* (taken three at a time) are used for exploring the longitudinal distribution of a film.



2 *Various arrangements of the triple-band system*
a As normally used.
b Line bands subdivided for circumferential mapping.
c Multiple bands for longitudinal mapping.

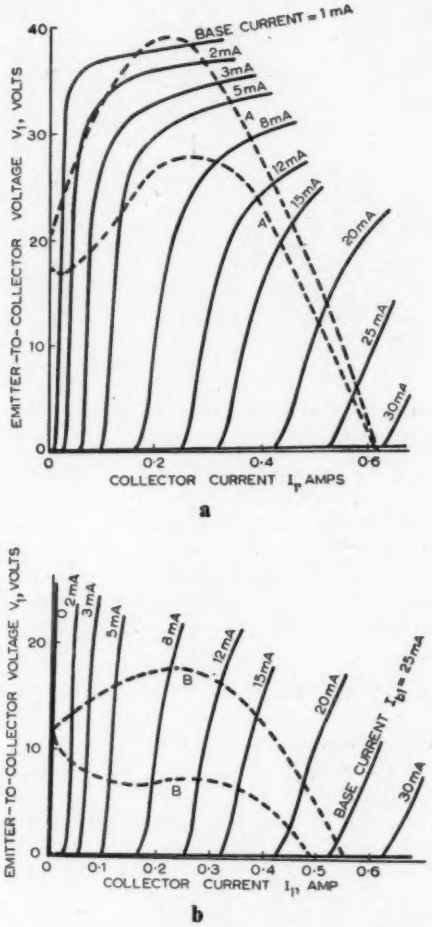
The method has been used in the discovery of a new valve phenomenon, which is the subject of another Institution paper.

621.317.331:621.385

Transistor Regulators

A short review of a Supply Section paper (No. 2334) entitled 'Transistor Voltage Regulators for Alternators', by E. E. Ward, Ph.D., Associate Member, and N. H. Sabah, M.Sc., Student. The paper is published this month in Part A of the Proceedings. Dr. Ward is, and Mr. Sabah was, in the Electrical Engineering Department, University of Birmingham.

IN SPITE OF THE GROWTH OF PUBLIC SUPPLY NETWORKS there is still a large demand for small alternators. In the industrial countries they provide stand-by supplies, and in isolated settlements and undeveloped territories they provide the basic supply. They are also needed for portable electrical installations and are fitted in aircraft and ships. Many of these machines are of traditional design and are excited by a coupled d.c. generator which is self-excited. The large inherent regulation of these alternators calls for an automatic voltage regulator, and it is the custom to design a new regulator for every new machine. Such regulators control the exciter field current by vibrating or rolling contacts, by a transductor or by a carbon pile. A regulator based on the junction transistor

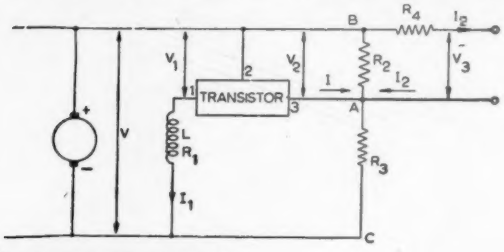


1 *Transistor common-emitter curves and load lines*
a With positive compounding. b Without compounding.

may be more robust than the present types, less affected by altitude and humidity (and by heat, if a silicon transistor is used), lighter and cheaper and small enough to be combined with its machine; it may be capable of controlling a wide range of machines.

The paper investigates circuits in which the transistor is in series with the field coil of a self-excited exciter, but the principles described would apply equally to an alternator self-excited by a rectifier. Common-emitter

connection is preferred, and Fig. 1 shows the load-line relating the transistor current, which is the field current, to the emitter/collector voltage, which is the difference between the field-coil voltage and the brush voltage. The transistor, like the pentode valve, will give stable control of the exciter voltage down to the remanent-magnetism



2 *General control circuit*

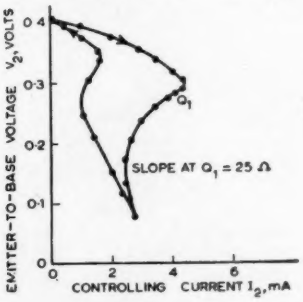
V = terminal voltage of the exciter.
V_1 = output voltage of the transistor.
V_2 = input voltage of the transistor.
V_3 = e.m.f. of the control source.
I = input current of the transistor.
I_1 = exciter shunt field current.
I_2 = control current.

level. The circuit used is shown in Fig. 2, and two sets of conditions are analysed:

(*a*) R_3 is low. If the control voltage V_3 vanishes (as on alternator short-circuit) full excitation is given; the conditions for stable control are derived.

(*b*) R_2 is infinite, R_3 is large. Stability is unconditional, but a special arrangement must be added to produce full excitation on short-circuit. This circuit is slower-acting and more complex than (*a*), but it gives closer regulation.

The paper gives test results on a 10 kVA 50 c/s machine having a 110-volt exciter of which the field current rises to 0·8 amp. The regulating transistor occupies 0·3 inch^3, weighs 1·1 oz and is rated to carry 4 amp. It is controlled by a small amplifying transistor, the load-line of which is shown in Fig. 3 for case (*a*). On throwing off a load of



3 *Input characteristic of potentiometer*

10 kVA at 0·8 lagging power factor, no departure from 230 volts can be seen on a meter scaled to 400 volts; the overshoot and damping are within acceptable limits.

621.316.722 : 621.314.7 : 621.313.322

Self-Compensated Alternators

A short review of a Graduate and Student Section paper entitled 'Principles of Self-Regulation in Rotating Machines', by P. J. Bhatt, B.Sc.(Eng.), Graduate. The paper is the Chairman's Address to the East Midland Graduate and Student Section delivered at Loughborough on the 1st November 1955, and it was awarded a Graduate and Student Premium by the Council. It was also read by the author at a meeting of the Utilization Section in London on the 14th February 1957.

WHEN A NORMAL D.C. GENERATOR SUPPLIES A LOAD, a drop in terminal voltage occurs, owing to the inherent resistance and reaction of the armature. If the machine is self-excited, this drop is further accentuated by the weakened excitation which results from this lower voltage. In an a.c. machine, this drop becomes more involved owing to the existence of load power factor.

The inherent voltage regulation of an electric generator is defined by the rise in terminal voltage when the full load is switched off, with the speed constant and the excitation maintained at the full-load value. In certain machines this regulation may be as high as 35% and may be undesirable for many reasons.

Many attempts have been made to design automatic control systems to regulate the excitation of a generator in such a manner as to maintain a constant terminal voltage over the working range of the machine. These systems fall into two groups:

(*a*) The feedback, or self-corrected, type.
(*b*) The functional, or self-compensated, type.

The feedback type of regulator is an error-actuated system. Its functions are to detect any deviation of the controlled quantity from its desired value (i.e. the reference), and to initiate a correcting action which reduces this error to a minimum, thus forcing the quantity under control to the required value or to a value very close to it. This type of regulator is expensive and generally requires skilled maintenance, but it gives fine, consistent regulation, both steady-state and transient, and is used with generators of large output.

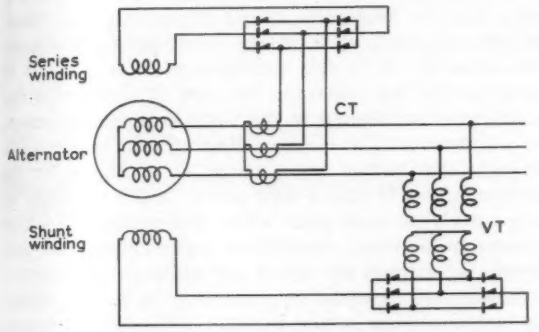
The functional type of self-regulation is generally applied to machines of small output, such as those used on isolated farms, mobile power stations or emergency lighting sets, where robustness, ease of maintenance, and economy in first cost are more important than accuracy of regulation. With such machines, the variation in excitation to maintain constant voltage under various loads is first determined. Certain chosen parameters of the system, such as current, power factor and speed, are then arranged to provide this variation, careful calibration being necessary. If, owing to changes in engine speed, temperature, hysteresis, etc., the excitation requirements of the machine differ from the predetermined 'law', the regulation will suffer. Unlike the feedback system, the compensated alternator is not conscious of its perfor-

mance and is unable to correct itself. When the self-compensated alternator is required to meet stiffer accuracy specifications, an additional feedback type of automatic voltage regulator must be used. It is small and not too expensive.

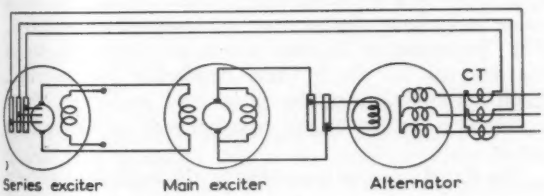
The feedback regulator is fundamentally a hunting system and requires stabilization. The functional type of regulation is an open-loop system and is very stable; it is practically instantaneous in action and hunting does not occur even with shock loading.

Series Compensation

For d.c. machines the only compensation available is from the load current. This current is passed through an additional (series) winding on the main poles in a sense which helps the main winding. As a result, the generator field is automatically and progressively strengthened with load. This is termed *series compensation*. In a.c. machines, compensation of this nature can be used to obtain *level compounding* (Fig. 1). In common with the



a



b

1 *Series-compensated alternator*
a With static excitation system.
b Without external rectifiers.

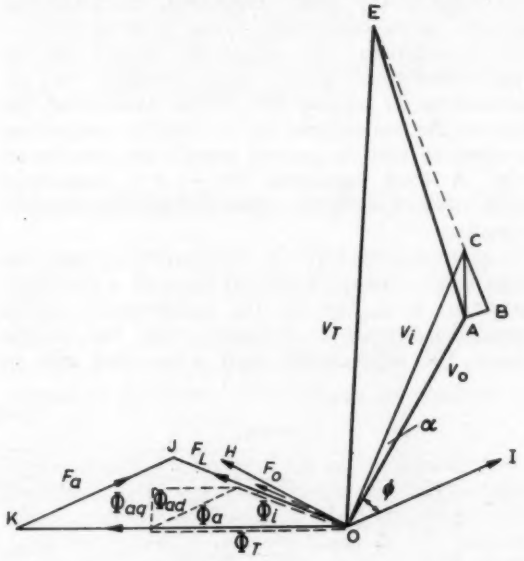
d.c. machines, this type of compensation has two failings, namely the regulation has a humped characteristic, and it is subject to variations in winding temperature. Furthermore, it does not respond to changes in the power factor, and it is applicable only in those systems where the load power factor is known and does not vary appreciably. However, it can give a regulation within commercial limits (5–10%) for small machines of about 30 kVA with constant power factor. When operating at a second power factor a series resistance can be switched in to alter the value of the compensation.

The no-load excitation is obtained from a battery or a separate exciter or from the line voltage. The series field may be arranged for direct excitation from the load current by means of single-phase or three-phase current transformers. Rectification may be carried out by means of dry rectifiers or by transformer action in a rotating armature. In the latter, illustrated in Fig. 1*b*, if the current from the current transformer is reversed in phase, the resultant field in the armature will be stationary in space. This stationary magnetic field is directed through unwound poles on the stator. A light separately excited winding on these poles provides a control of the compensation. In this arrangement the variation of load power factor causes the armature field to shift, and to counter this the stator can be arranged for rocking.

Phase-Discriminatory Compensation

When regulation over a range of load power factors is required, the power factor is made a controlling parameter, and the regulator becomes phase discriminatory. To effect this, the compounding must be vectorial, i.e. the series and shunt components must be added together in the a.c. state.

The vector diagram for an ideal alternator is illustrated in Fig. 2. It is seen that the correct excitation requirements can be provided by the vectorial summation of two



2 *Vector diagram of an alternator*

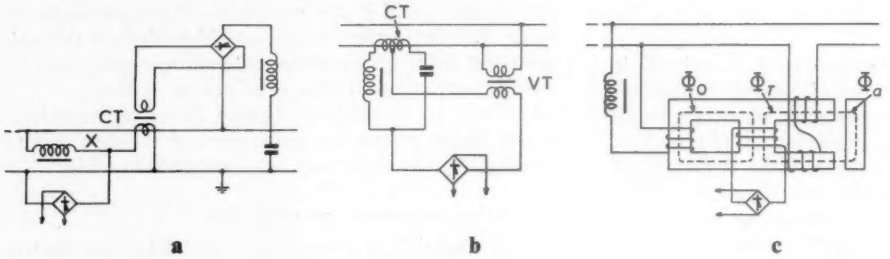
OA = terminal voltage V_o.
AB = armature IR drop.
BC = armature reactance drop.
OC = internal voltage of alternator V_i.
OE = total generated e.m.f. V_T.
OI = load current.
OK = total excitation F_T.
KJ = armature reaction F_a.
OJ = effective excitation F_i.
OH = no-load excitation F_o to generate V_o.
Φ_T = total armature flux.
Φ_a = armature reaction flux.
Φ_{aq} = armature cross-flux.
Φ_{ad} = armature demagnetizing flux.
Φ_l = effective flux.

voltages, currents or magnetomotive forces, one (OA) dependent upon the machine voltage, and the other (AE) proportional to the load current. The angle of compounding, OAE, depends on the load angle ϕ and the angle α of the internal impedance triangle.

Typical arrangements for *pre-rectification* summation are shown in Fig. 3. In the method shown in Fig. 3*a*, a current transformer connected to an impedance X simulates the internal drop AE both as regards magnitude and phase. This voltage is summed with the generator or terminal voltage to give the required excitation. The compensation is not perfect, but it could be made so ($\pm 0{\cdot}6\%$ is claimed) by means of a voltage-sensitive circuit comprising a capacitor tuned to an inductor which saturates the current transformer.

In the method shown in Fig. 3*b*, the voltage transformer supplies the shunt component, the additional quadrature series component being obtained from a current transformer. An adjustable air-gap on the current transformer allows small variation of the compensation. By tapping the current transformer, the voltages in the two sections can be made to compensate each other, so that the current transformer absorbs no voltage. A total regulation of $\pm 1{\cdot}5\%$ (sometimes $0{\cdot}75\%$), is claimed for all power factors from unity to zero lagging.

The compensation may also be obtained by summing voltage- and current-proportional fluxes in a three-limb transformer, as in Fig. 3*c*. The shunt-excited limb is designed to saturate at voltages below that of the machine. The series-excited limb is provided with an adjustable air-gap and is substantially unsaturated. The output winding is on the central limb and embraces both fluxes, and it thus follows the excitation requirements of the alternator. A regulation of $\pm 2\frac{1}{2}\%$ is readily obtained.



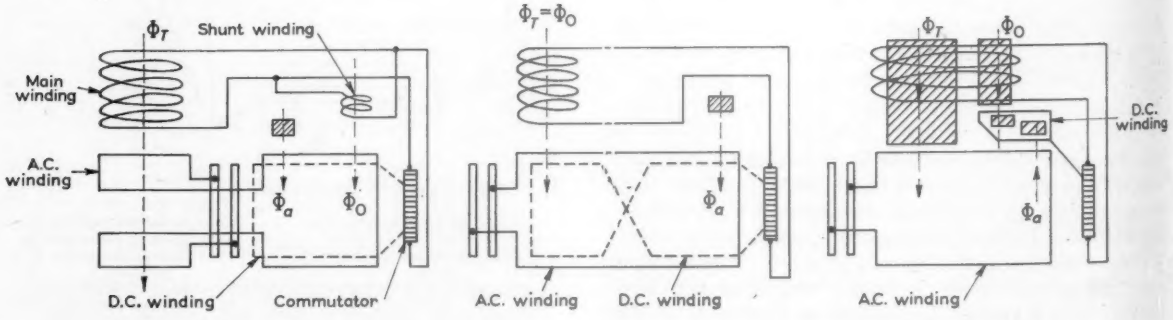
3 *Phase-discriminatory compensation*

Intrinsic Compensation

The circuits of Fig. 3 are shown as single-phase units. With unbalanced loads, or when larger alternators are considered, a three-phase arrangement must be used. It may also be necessary to use a separate co-rotating exciter, the field of which is controlled by the static compensator. With this arrangement it is possible to combine the two armatures into one structure. The d.c. conductors are wound in the same slots and connected to a commutator at the non-slip-ring end. It is possible to go a step further and arrange, as in Fig. 4, for the compounding of shunt and series fluxes (Φ_0 and Φ_a respectively) to take place within the machine. Such an alternator becomes intrinsically self-exciting and self-regulating without the use of any external equipment.

Ideally, the magnetic core carrying the flux Φ_0 should be highly saturated whilst the path of Φ_a remains unsaturated. It is also desirable that the a.c. armature, which carries the flux Φ_T, shall have normal saturation, i.e. a value just above the bend on the magnetization curve. The performance of the alternator depends upon the manner in which these desiderata are satisfied. Each combination results in a new machine, whose accuracy is limited by the compromises that have been made.

The flux Φ_0 can be generated by the main field or by a



4 *Intrinsic compensation in alternators*

winding in parallel with it. The parallel connection of Fig. 4*a* is equivalent to a separately excited alternator. The two fluxes Φ_0, Φ_T traverse different paths and can be designed separately. The arrangement is very flexible and seems the most convenient.

When a common winding is used, as in Fig. 4*b*, the a.c. armature also carries the d.c. coils, so that Φ_0 and Φ_T are equal. This arrangement is the a.c. equivalent of the shunt generator. Thus with leading power-factor loads, when Φ_T is very weak, the machine operates on its linear, or air-gap, line and is unstable. To remedy this, the poles may be split, as shown in Fig. 4*c*, and designed individually. However, the proximity of the two poles creates a leakage flux between them, which upsets the normal relationship by an amount which varies with load.

The series flux Φ_a may be produced by a transformer action similar to that in Fig. 1*b*. An unwound ring worked at a feeble saturation, as in Fig. 4*b*, will have a linear current-dependent flux induced in it. Alternatively, a Gramme-ring construction like that of Fig. 4*c* can be used, forming in effect a rotating-field current transformer. An axial displacement of these rings varies the effective air-gap and provides an adjustment of the compensation.

To obtain the correct phase relationship, Φ_a and Φ_0 must be in phase quadrature at unity power factor. Since Φ_a is in phase with the load current and Φ_0 is in quadrature lagging to the voltage, one of the fluxes must be reversed before the summation. In Fig. 4*a*, the reversal is effected on the exciter field. With split poles it is necessary to transpose either the a.c. or the d.c. windings. The d.c. windings are of light section, and are easily reversed. In the system of Fig. 4*c*, the Gramme ring is arranged such that Φ_a and Φ_0 act on opposite faces of the ring, so that correct compounding is obtained without any transposition of windings.

Compensation can also be obtained by placing a pair of brushes in quadrature to the main brushes. On these brushes is imposed a voltage which is proportional to the armature reaction and is appropriate for compensation. A similar effect can also be obtained by rocking one or both main brushes backwards in the direction of rotation. The system is the a.c. equivalent of the compound generator and is not really phase discriminatory.

621.313.322

SYNOPSES OF PAPERS

Nuclear Reactor Development

A synopsis of a paper (No. 2363) entitled 'Development of Gas-Cooled Reactors for Power Production', by R. V. Moore, G.C., B.Sc.(Eng.), M.I.Mech.E., Member. The paper was presented to the British Nuclear Energy Conference on the 22nd November 1956. It will be published in the Journal of the British Nuclear Energy Conference and also in Part A of the Proceedings. Mr. Moore is with the United Kingdom Atomic Energy Authority.

THE PAPER REVIEWS THE POSSIBLE DEVELOPMENT OF gas-cooled graphite-moderated reactors for power production. It is shown that larger reactors of the Calder Hall type will produce electric power at a competitive cost in the United Kingdom.

A very promising line of development is towards higher-temperature operation, since this increases both the heat rating of the reactor and the overall efficiency of the plant, although it requires the development of new materials, particularly for cladding the uranium. As higher temperatures are reached, interest is stimulated in the oxide and carbide forms of uranium, and for very high temperatures an all-ceramic reactor core has been suggested.

The paper describes the use of recycled plutonium as a fuel, showing that under certain circumstances this is possible with a natural-uranium fuel. Comparison is also made of the relative merits of a number of possible coolant gases.

It is concluded that, given research and development effort, the gas-cooled graphite-moderated reactor is capable of considerable development. For the base-load application, cheaper power should be possible, and the range of application may be extended to smaller power units tailored for specific purposes. 621.311.25

Diode Capacitance and Space Charge

A synopsis of a Radio and Telecommunication Section paper (No. 2333) entitled 'The Capacitance between Diode Electrodes in the Presence of Space Charges', by C. S. Bull, Ph.D., Associate Member. The paper will be published in Part B of the Proceedings. The author is Lecturer in Physics at the College of Technology, Birmingham.

THE CAPACITANCE BETWEEN THE ELECTRODES OF A PLANAR condenser with no space charge can be calculated by finding the rate of change of charge on either electrode with the potential between them. In the presence of space charges, however, the result is different if the charge on the cathode is considered rather than the charge on the anode. The method is therefore not valid in this application.

These results have a bearing on the efficiency and design of klystrons, affect the theoretical position with regard to the fluctuations of diodes and reveal errors in the equations hitherto commonly used in the study of electron-inertia effects. 621.385.2 : 621.3.011.4

4. THE MANAGER AND FINANCE

by H. A. V. Bulleid, M.A., M.I.Mech.E.

In this article Mr. Bulleid, who is Production Manager of British Nylon Spinners at Pontypool, crisply sets out a few salient ideas on company finance. They are addressed primarily to engineers in industry who regard financial data with suspicion or lack of understanding, but many others will appreciate Mr. Bulleid's shrewd and pithy comments. Before coming to the 'narrow picture' of management accounting, which shows the use of financial devices for control, he throws a glance at the 'broad picture' of a company's whole financial performance—a picture which should indeed be 'grasped by all managers'. Mr. Bulleid speaks personally to the reader, and he speaks out of his own experience. He would not have the engineer-manager become bogged in accountancy, but he emphasizes the value of accurate budgeting and costing techniques, and he does not hesitate to throw in a little elementary advice on the reading of accountants' figures. A salient point he makes is that 'overall company financial returns generally mask lower management effort'; production managers should thus assess clearly the profitability of their own departments.

Previous articles in this series appeared in the March, April and May issues of the Journal.

SOME engineers feel they can control costs by working on 'hunches'; others fear or dislike accounting information, which, naturally enough, lacks technical optimism; and still others have been wholly rapt in the arts and techniques of engineering and have cheerfully let someone else come in to control the business aspects of their work. We might as well face this last feature squarely: the accountants obtained their charters in the eighteen-seventies, compared with the engineers in the nineteen-twenties, which surely indicates broader thinking. Nowadays, with larger manufacturing organizations, taxation implications, and the requirements of Board of Trade and other returns, the guidance of good accounting is essential.

Wrongly based financial data may be mainly the fault of the technical manager, who should guide the accountant in technical matters and, in return, is entitled to an objective appraisal of projects and of progress, unbiased by technical considerations.

Financial data give the broad picture of how well a company is 'keeping up with the Joneses'. The technique is financial accounting, which is explained below by means of an example. Both in financial accounting and in the three other phases of the broad picture described, namely depreciation, inflation, and economic controls, I have included some details of technique, but I have been generally more concerned with illustrating the essential need for co-operation on every point between accountant and manager.

The broad picture should be grasped by all managers; but, equally, they should be willing to delve into detail to ensure operating efficiency and prevent waste—even if the inefficiency and the waste were too small to show in a board report. For this reason, I have also framed the narrow picture—thus moving from the board room to the departmental manager's office.

The Broad Picture

The policy makers of a manufacturing organization may favour one of three slants: to provide goods or services at the best value for money; to make the maximum possible profit; or to acquire the maximum possible prestige. But whatever the policy, it will be affected by the performance of similar organizations in this and in other countries. For these essential comparisons, financial accounting is the only known yardstick. In order to see and understand the broad picture, therefore, the manager must be able to read with discernment companies' accounts and linked financial opinion, as reported, for example, in the *Financial Times*.

Financial Accounting

The manager should understand double-entry accounting and the distinction between capital and revenue. The textbooks (see, e.g., Chapter 8 of Reference 1) explain these; briefly, *capital* refers to any alteration in the assets value of the company, whereas *revenue* connotes gain or loss on trading.

The accountant, guided by technical staff for items 1, 2 and 3, can thus express in financial terms the company's performance:

	Capital Accounts	*Debit Balances* £	*Credit Balances* £
1	Buildings	20000	—
2	Plant (less Depreciation)	30000	—
3	Cash, Debtors	5000	—
4	Closing Stock-in-Trade	6000	—
5	Trade Investment	3000	—
6	Share Capital	—	50000
	Balance (= Net Income)	—	14000
		£64000	£64000

Revenue Accounts	*Debit Balances* £	*Credit Balances* £
1 Production Expenses and Purchases	27 000	—
2 Salaries and Wages	23 000	—
3 Plant Depreciation	3 000	—
4 Rents and Rates	2 000	—
5 Income from Trade Investment	—	500
6 Stock, Opening and Closing	4 500	6 000
7 Sales	—	71 000
8 Administration and Research Expenses	6 000	—
9 Royalty Receipts	—	2 000
Balance (= Net Income)	14 000	—
	£79 500	£79 500

These simple annual lists show you, as a manager, (if you acquire the sight) two fundamental sets of information: how the company is doing compared with last year, and how the company is doing in proportion to its size and in proportion to how other companies are doing. Usually, more detail is given than in the abridged example above, and this further fills in, against the broad picture, the performance, for example, of the production department against the sales department.

Whether such accounts also indicate the effect of your requests for capital for new plant and your savings on labour depends entirely upon the relative size of your department in the entire organization: it is unfortunate that, through sheer size, the overall company financial returns generally mask lower management effort, and this is an argument against linking the production budget too closely with the company's financial statement.

Depreciation: Plant and Buildings

Your production maintenance charges are obviously revenue; so too, though less obviously, are minor machine improvements. All maintenance and modifications which keep your plant in its necessary top-class condition throughout its ten- to twenty-year life, are revenue charges. You capitalize a plant alteration only when thereby the (duly depreciated) capital value of the plant is enhanced.

Depreciation is a method of holding earnings as retained profits, at such a rate that they will provide enough to replace plant when it needs replacing. But whether or not to renew this plant at the point where it is written off—i.e. the necessary cash has been set aside to repurchase—should be a straightforward matter of engineers making their case. The accounting process earmarks replacement cash at the earliest moment that the technical man has warned that he may require it. It is a financial function, based on the technical case for replacement and many other considerations, to decide how the earmarked cash should in fact be used (Reference 1, Chapter 15).

Depreciation of buildings is more prophetic than realistic, because they last more than a generation, and thus *unaccountable* circumstances are likely to override *accountable* depreciation.

Inflation

The foregoing will seem to contain a fallacy if your experience is limited to an inflationary period. This is true, and the situation is worsened by heavy taxation. Suppose you had a car costing £500, and four years later you came to replace it and found that you had £500 in saved cash and that the replacement car would cost £800. Your car-purchasing income being taxed at 8s. 6d. in the pound, you would be able to make the replacement only with your set-aside cash *plus* an additional earning of $(20/11\frac{1}{2}) \times$ £300, or £522. Clearly this would be no embarrassment if you foresaw it, *and* your salary went up in line and in time with inflation, *and* income-tax limits marched in step.

A company might well have to find nearly £500 000 to replace plant originally costing £100 000, owing to trebled plant cost and $45\frac{1}{2}\%$ taxation. Thus

$$£100\,000 + \left(\frac{100}{54{\cdot}5} \times £200\,000\right) = £467\,000$$

The same troubles apply to stocks of raw materials and finished goods, many of which have an odd way of losing value even in times of inflation. So the production man controlling stocks should, where possible, hold these to a proportion of the estimated consumption for, say, the next thirteen-week period, co-operating with the accounts department on values and on stocktaking, and above all bearing in mind that large stocks and masses of work-in-progress point to ineffective production and stock control.

Economic Controls

A company's performance can further be affected by such outside influences as cold wars and credit squeezes, and this further underlines the need for a glance at the broad picture. Apart from these two rather extreme examples, there are always certain monetary controls in force and the effects of these on a certain production line can be large compared with technical effects; so they must be heeded.

The Narrow Picture

Crisp and cordial interdepartmental co-operation is essential if cost control is to be effectively applied. There are always opposed slants—quality against cost, speed against cost, stock against space; and only when the full data have been furnished to the accountant can he assess the cost to production of any particular quality improvement, improved delivery time or stock safeguarding.

Though many are Scots, some cost accountants forget that 'many a mickle maks a muckle'. They may, quite rightly, say in response to a sales-department servicing query that doubling a certain maintenance squad would have an insignificant effect on the total production cost. The danger of this will be readily apparent to anyone who has been in charge of production, and accountants themselves see it in such contexts as housekeeping money. But it is always hard to challenge people for taking too

broad a view: if you are fighting costs which are marginal, then aid your fight with a more detailed view of these particular costs, when they will no longer appear marginal.

Cost Accounting

Here are two examples, one from a processing and one from an equipment manufacturing company, showing how the cost accountant should illustrate the proportion of general production costs in the product selling price:

	1 PROCESS INDUSTRY	2 EQUIPMENT MANUFACTURING INDUSTRY
	Per Hundredweight of Product	*Per Item of Equipment*
	s. d.	s. d.
Raw material	4 0	2 0
Waste and sub-standard product	6	2
Direct labour	6	2 0
Maintenance labour	1	1
Services, packing and dispatch	9	4
Factory expenses (including depreciation)	9	2 0
Therefore factory cost is	6 7	6 7
Suppose Research + sales + head-office overheads total	x	x
Then company cost is	(6s. 7d. + x)	(6s. 7d. + x)

The overheads x may vary from five times to one-fifth of the factory cost, according as the product varies from cosmetics to substation equipment. If you do not know your x, you cannot understand the relative importance of your contribution to your company's profitability.

Column 1 shows comparatively large material cost at eight times the cost of direct labour: with full automation, this ratio would be infinite. Column 1 also shows an effect common to the process industry in that waste can represent a cost equal to direct labour, compared with less than one-tenth of direct labour in Column 2. Column 2 shows factory overheads as 100% of direct labour, this being a commonly discussed ratio, the significance of which diminishes as mechanization increases.

Both examples show maintenance labour as the same proportion of factory cost, but in Column 1 it is four times greater than in Column 2 when taken as a proportion of direct labour. These proportions are an essential part of your case when pin-pointing certain facets of production expenses in setting production standards.

Standards

Two everlasting production problems are: preventing a drift back towards inefficiency; and bringing in new methods to ensure improved efficiency. The first of these is particularly aided by setting standards of operation and having the cost accountant make a monthly check of actual performance against these standards. How accurately standards can and should be set is a matter of judgment (Reference 2, p. 47).

It is very important for the production manager to ensure that standards do not stop short at the production stage—they must go right through into the warehouse, because it is clearly a waste of energy having an alert production squad saving pounds while a dilapidated sales manager is selling everything at a discount and wasting pounds. It is managerially bad if, for example, a sales manager and a chief accountant, who may happen to be in management positions senior to that of their works manager, adjust selling costs in relation to production costs without telling him; for this drives a wedge between shop-floor effort and general result, and although the shop floor should work to instructions, these instructions ought to be fully understood at the works manager's level.

The Budget

When standards have been set and allowances or variances agreed to cover special conditions, the works budget may be compiled, giving expected costs and expected monthly production achievements; so that when the actual costs and actual achievements are filled in each month, performance can be measured.

The route to the works budget is: sales plan → production plan → plant loading → labour, methods, materials → budget.

Obviously, there must be a commercial, and hence a sales, plan (Reference 3, p. 16). It is far different planning how many kilowatt-hours of electricity you will sell compared with planning how many multi-million-pound power-station contracts will come your way, or how many thousands of fractional-horse-power motors you will be called upon to supply; every man to his own job, and it is the job of the commercial and sales people to give the production department accurate short-term, and reasonably accurate long-term, sales plans.

Only then can a production plan be made. You might be lucky and merely have quantity variations on a job which is entirely covered by standard costs. Far more likely, you will have to compare plant availability with delivery dates, and decide what additional costs you will incur by overtime, or by making components in the wrong order and, therefore, having to store them, in order to keep bottle-neck plant continuously occupied.

In further detail, plant loading can now be worked out to suit the production plan. This should include occupation of manufacturing capacity; labour with overtime allowance; consumable materials; raw material, together with the standard rejection rate; services; finished-part stock levels; distribution costs; and any agreed proportion of head office, building and other costs.

From these facts the budget is prepared, normally for each financial year. If a new or altered process is planned, the normal procedure is to get the cost accountant to do a preliminary costing exercise and agree provisional standards for a period. Revision of the budget and

incorporation of alterations should be at an agreed frequency.

The amount of detail in the budget should be just so fine that a foreman can see the effect of action in his section on the whole budget. Anything coarser is frankly of little use to the shop manager because it does not give him a message he can put over to a foreman. Anything finer is likely to be rather costly. Another reason for not going into much fine detail is that there is a limit to the accuracy of shop-floor bookings as well as to the accounting accuracy of material allocations. The optimum frequency of returns depends entirely on how they will be used (Reference 4, p. 10).

If you succeed in obtaining a budget revision at a reasonable frequency, say every two or three months, and in not too much detail, clearly you can harness this as a useful method of obtaining sanction for alterations to your stores stock items, or for the institution of such additional operations as may be called for by the sales department to refine the product. For example, a new individual package, costing you an additional £x per month at your standard production rate, can be presented in such a revision for its formal financial sanction.

Capital Sanctions

Particularly in process industries, the slick obtaining of capital sanction is not easy, however helpful all the other managers may be. A common pattern of rejoinders confronts you when you wish to install a second machine for one operation in a production line and the case is marginal:

1 The existing machine will process 95% of the output.
2 Sales may fall.
3 The need for the operation may change.
4 The existing machine might be speeded up.
5 To buy an exact replica without technical advances would be spineless.
6 Because of 5, there is no time if you want the extra production in a hurry.
7 There is scarcely room.
8 Why did you not ask earlier, before there was a production back-log to catch up on?
9 Is it worth the expenditure?

The sales department is dead certain about 9 but evasive about 2. The accounts department appears suspicious of items 1 to 9 inclusive. The design department is coy about 5 and certain about 6. The works manager is depressed about both 6 and 8, having worked long and hard to push up productivity from 95% to a safe 105% and only just failed.

So, as always, you have to work hard to present as clear a case as possible—and note that objectivity is best preserved if the management team is mutually sympathetic. And, of course, an accurate budget with a reasonable revision frequency will at once throw such a project into perspective; it will even hold the perspective when the sanction is overspent.

Accurate budgeting and costing techniques will also help you in the approach to some estimating difficulties. For example, if a £2000 project is going to save £600 of direct labour per annum, it is obviously so advantageous that the degree of estimating accuracy for the first cost cannot matter within 20%. Thus you have an unassailable case for obtaining sanction on a provisional estimate to an accuracy of $\pm 20\%$, with perhaps a time allowance of three to four months for a revised estimate when firm quotations and other cost data become available. Some decisions of this nature may be eased by operational research techniques (Reference 5).

Profitability

The narrow picture of profitability can be shown with great clarity from comparisons of budget and actual performance, coupled with whatever accounting device you have arranged to link your performance with company profitability.

When you have got your standards as you want them—and they must be fluid because your wants vary from time to time—they will readily throw up the effect, for example, of creeping overtime, of having to hold a displaced labour squad during a production switch, or of an excessive deployment of methods-section effort to one product.

Most manufacturing organizations have maximum profitability as their main objective. Selling goods is in fact selling the service of converting raw material into those goods. This conversion cost can vary a great deal on different jobs, and their profitability, rather than the more narrow efficiency of your own production performance upon them, must be the basis of the amount of technical work you can apply to improving production (Reference 1, p. 167).

It is difficult from a works manager's viewpoint if different components carry different profitabilities, because then, clearly, plant occupation is not directly related to profitability and there is a danger of the business leaning on what could be the short-term profitability of one production. Moreover, non-uniform product profitabilities make it only too easy for one product to subsidize another. In the same way, the works manager can further be indirectly hindered if he is ignorant of sales variations due to such manoeuvres as substandard manufactures being taken into stock at zero value and then sold off at only a small discount.

However, one must be realistic, and such difficulties are bound to arise in industry, and therefore the difficulties of the works and production managers should be minimized by taking them into the picture and reducing their chances of wasting the company's total effort in applying it to non-profitable products.

The broad picture of profitability emerges when you display the narrow picture of your own production organization as part of your own company's financial performance and then compare this with outside competing influences, as shown in the published financial reports of other companies.

Conclusion

The chief accountant's function can be regarded as having four facets: presenting the company's balance sheet in line with legal requirements; generally guiding high-level management on financial matters; determining taxation effects; and cost accounting, which is mainly factual and reporting, and is analogous to the operational side of engineering. In this connection, some annoyance may be caused by a cost accountant claiming to 'reduce' costs when he is merely reporting, rather after the event, the success of your own cost-cutting plan; but in fact the cost accountant may be able to add many clues to improving your plan (Reference 6, p. 10).

The larger organization may have a treasurer or a separate manager in charge of finance who, taking the results put up by the accountant will formulate decisions on new capital schemes, the allocation of moneys, and credit control (Reference 4, p. 18).

In all such decisions the chief accountant, the treasurer or the finance manager is, of course, dependent on his other management colleagues, and so the conclusion emerges that, as with all these functional helps to management, the full value is obtained only if the management team works together sympathetically.

References

References in the text are made to the following six publications. Parts of these are rather boring, but much is very interesting, and they contain some useful and perhaps some noble reading.

1 BOND, G. D.: 'Financial Aspects of Industrial Management' (Butterworth, 1955).
2 JARDINE, P.: 'Standard Costing and its Relationship to Work Study', *Time and Motion Study*, August 1956.
3 'Production Control and Related Works Statistics'. Report of a Joint Committee of the Institute of Cost and Works Accountants and the Institution of Production Engineers, 1956.
4 'Management Accounting' (British Productivity Council, 1950).
5 BEER, STAFFORD: 'Operational Research and Accounting', *Operational Research Quarterly*, March 1954.
6 'Cost Reduction' (Institute of Cost and Works Accountants, 1956).

OBITUARY

JOHN BREARLEY LEES

John Brearley Lees died on the 29th January 1957, after a very short retirement that was brought about by ill health. He was born on the 3rd August 1898 in Oldham, and was educated at the Freehold School, Oldham, at the local technical college and later at the Manchester College of Technology.

He began his service in the electrical engineering industry with Ferranti Ltd., working on switchgear and power transformers, and spent some four years in the Army with the Royal Engineers (Signals) in the First World War. After demobilization, he returned to Ferranti Ltd., and spent some time in the meter and instrument test departments. This was followed by a period as outdoor inspecting engineer, covering the whole of the British Isles. After a short time with the Electrical Apparatus Co. in London, he joined the staff of the Oldham Corporation Electricity Department in 1925 as an assistant mains engineer, where he supervised the Test Department.

In 1935 he was appointed Deputy Electrical Engineer to Sale Corporation, and in 1940 he was promoted to Chief Electrical Engineer. He held this position until the nationalization of the industry in 1948, when he was appointed District Consumers' Engineer with the North Western Electricity Board, serving first in the South West District and then in the North District of the Manchester Sub-Area.

For his paper entitled 'The Equipment and Operation of a Modern Meter and Test Department', published in the *Journal* in 1934, he was awarded a Meter and Instrument Section Premium.

Lees was intensely interested in his work, especially when he was Chief Electrical Engineer of the Sale undertaking, and, whilst the cares of office appeared to rest rather heavily upon his shoulders, he undoubtedly derived much pleasure from the conduct of this undertaking. Although he had a responsible post, he never really understood his position in a nationalized industry, having become completely engrossed in the Sale undertaking, which he regarded as his own particular job. Even so, he did sound work for the North Western Electricity Board, because he was a good engineer at heart and he enjoyed the confidence of his fellows.

At one time Lees was a keen golfer, and took an interest in freemasonry. He is survived by his widow and a married daughter.

He joined The Institution as an Associate in 1931 and was elected an Associate Member in 1932 and a Member in 1940.

T. E. D.

ALFRED GEORGE COLLIS

Alfred George Collis, who died on the 11th November 1956, was born on the 14th September 1881. He received his practical training with Veritys Ltd. from 1892 to 1901, during which period he studied part-time at Birmingham Technical School. He afterwards worked as an assistant engineer with the British Thomson-Houston Co. and with Ferranti Ltd. He joined Crompton and Co. at Chelmsford in 1912, and became Chief Switchgear Engineer.

Mr. Collis took a lively interest in local affairs and was always active in the organization of entertainments at Christmas for the poor children and the old folk of the town of Brentwood, where he lived for many years. He was sometime Chairman of Brentwood Urban District Council, served on Essex County Council, and was a Justice of the Peace. Mr. Collis also took a keen interest in local sport: he was a Vice-President of Brentwood and Warley Football Club, and was responsible for the introduction of public swimming baths and playing fields at Brentwood.

While in the employ of Crompton and Co. he inaugurated the Brentwood District Electric Supply Co., of which he was Chairman from 1920 to 1922, and later Managing Director. He was also a Director of Brentwood District Installations Ltd. In 1940 he joined the staff of the Director of Electrical Engineering, Admiralty, Bath, as a technical officer, serving in this position until 1949, when he founded the consulting firm of Collis and Partners in Bath.

Mr. Collis was the author of numerous technical papers on high-voltage switchgear and circuit-breakers, as well as several books, including 'High and Low Tension Switchgear Design' and 'Switchgear', published in 1913, and 'Practical Control of Electrical Energy', published in 1923.

One feels sure that there will be many in the electrical engineering profession who will regret the passing of so popular a figure. He is survived by his widow, two sons and a daughter.

Mr. Collis joined The Institution as an Associate Member in 1909 and was elected a Member in 1929.

H. H. S.

TECHNICAL PUBLICATIONS

BRITISH STANDARDS

Copies of the following publications can be obtained from the British Standards Institution, 2 Park Street, London, W.1. The prices given are post free.

B.S. 229: 1957 **Flameproof Enclosure of Electrical Apparatus** 7s. 6D.

This revised Standard deals with the enclosure of electrical apparatus for use in situations where inflammable or explosive gases or vapours may be present.

The method of assessing the statistical maximum safe gap for gases and vapours has been reconsidered, and a method of grouping more precise than that of the 1946 edition of the Standard has been evolved. Requirements for the sleeve bearings of large rotating machines for gases and vapours have been changed to make the construction and operation of the apparatus more practicable.

B.S. 587: 1957 **Motor Starters and Controllers** 8s.

This revised Standard now applies to a wide range of different types of hand-operated and automatic starters and controllers as used with a.c. motors of rated voltage up to 11 kV and d.c. motors of up to 650 volts. Requirements for resistors, auto-transformers and similar equipment associated with motor control gear are also included.

Standard ratings are specified, and standard sizes of starters and controllers are given in terms of motor horse-power. Full details are included of the standard duty ratings for resistors for use in motor control gear which have been generally recognized in industrial practice and in previous editions of B.S. 587.

The design and constructional requirements deal with many aspects of control gear, including, for example, details relating to mounting, provision for earthing and earth continuity, preferred standards for push buttons and indicating lamps, under-voltage and overload devices, over-current and breaking capacities, etc.

Type tests, routine tests and limits of temperature rise are specified.

B.S. 2613: 1957 **The Electrical Performance of Rotating Electrical Machinery** 7s. 6D.

In the latest edition of B.S. 2613 the load-with-overload basis of rating has been eliminated, and all machines have either continuous ratings or short-time ratings. The other principal change from the previous edition lies in the section dealing with temperature rise, where five classes of insulation are now specified.

In other sections, types of enclosure are classified, preferred horse-powers and speeds are given, and the requirements for type and routine tests are specified.

B.S. 2782. Part 2: 1957 **Methods of Testing Plastics. Part 2. Electrical Properties** 5s.

Part 1 of this Standard dealt with 'Effect of Temperature'. Part 2 specifies tests to be applied to moulding and extrusion compounds, to synthetic resins and their solutions, and to semi-fabricated products such as sheet, thin film, rod and tube. The tests relate to the electric strength, volume resistivity, surface resistivity and insulation resistance, and to the power factor and permittivity at 50 c/s, 800–1 600 c/s, and 10 kc/s–100 Mc/s.

Under each of the above headings requirements are specified for the form of the test specimens and the number to be used, the apparatus and the procedure and method of reporting.

B.S. 2844: 1957 **Memorandum on Standard Conditions for Use during the Testing and Pre-Conditioning of Electrical Insulating Materials** 3s.

This Memorandum has been prepared to bring together in a single publication the conditions of temperature, atmospheric humidity and liquid immersion which are in general use in the United Kingdom for the testing of electrical insulating materials and their pre-conditioning before test.

The range of standard conditions dealt with is wide enough for suitable conditions to be selected, so that either of the primary objects of conditioning can be achieved. These objects are to obtain great reproducibility of test results and to determine in what way exposure to certain temperatures and humidities affects the properties of a material.

B.S. 2848: 1957 **Flexible Insulating Sleeving for Electrical Purposes** 6s.

This new Standard specifies requirements for a range of flexible insulating sleeving of circular section, intended primarily for insulating electrical conductors and the connections of electrical apparatus. The sleeving may be made by varnishing or coating a textile base; or by extruding suitable insulating materials, with or without a textile base.

In selecting, from the number of different types specified, the most suitable sleeving for a particular purpose, consideration should be given to such general factors as operating temperature range, electrical requirements, climatic conditions, degree of fire resistance and the need for mechanical reinforcement, i.e. external braid, and the effects of impregnating media and of oil and other liquids with which the sleeving may come into contact.

B.S.I. Yearbook for 1957 15s.

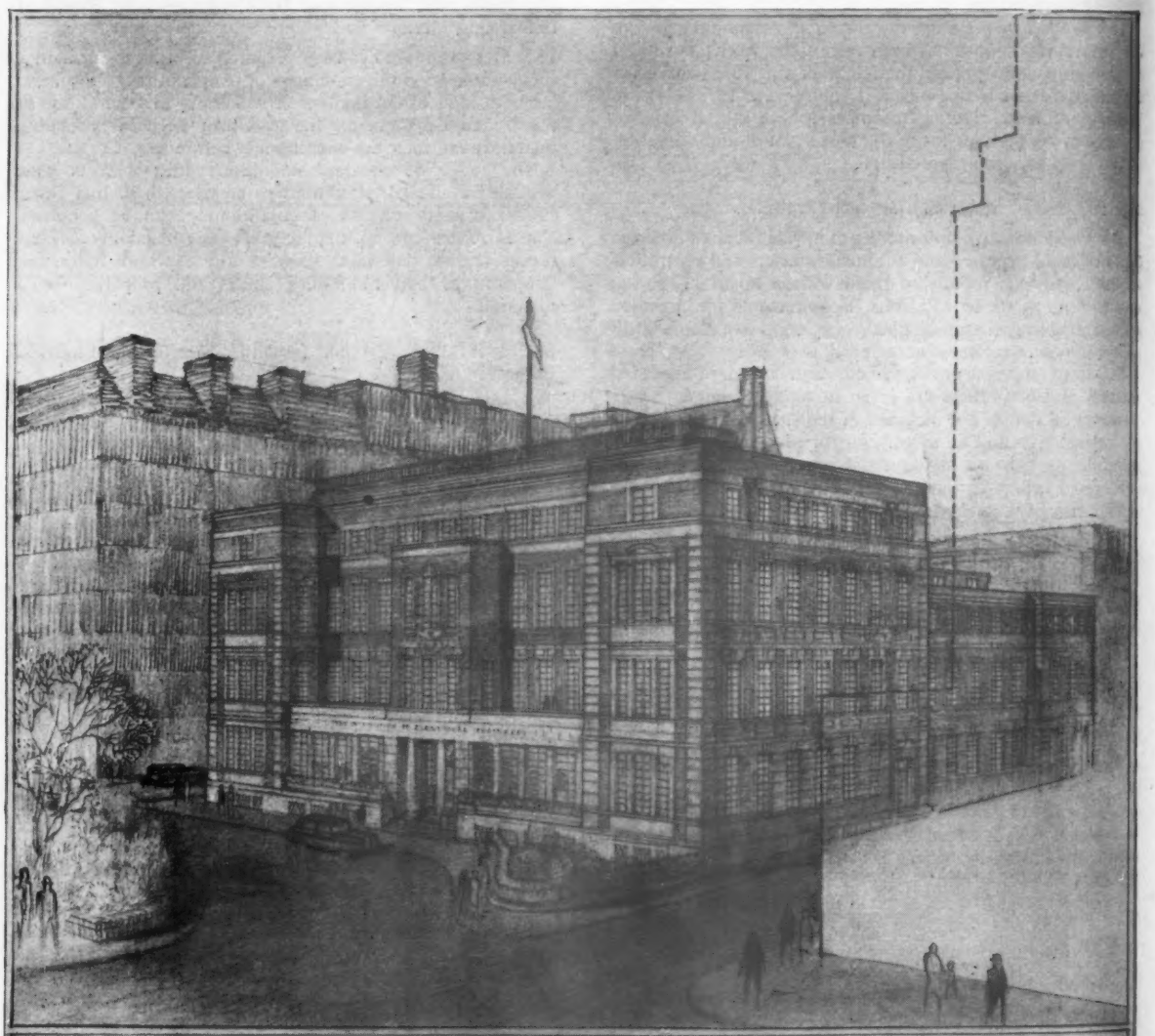
The Yearbook of the British Standards Institution contains 480 pages, of which 400 are devoted to a complete numerical list of the British Standards and Codes of Practice current on the 1st January 1957. There is also a comprehensive index in which all Standards are listed according to subject.

Apart from its main purpose as a reference directory to all current British Standards, the Yearbook contains other information about the B.S.I. and the services it offers, including notes on the British Standards mark of approval (the kite) and the Standards to which it applies, and details of the Canadian approvals service, whereby electrical gear can be 'approved' for export to Canada before leaving this country. Lists of addresses in the United Kingdom and oversea are provided where complete reference sets of all British Standards can be consulted.

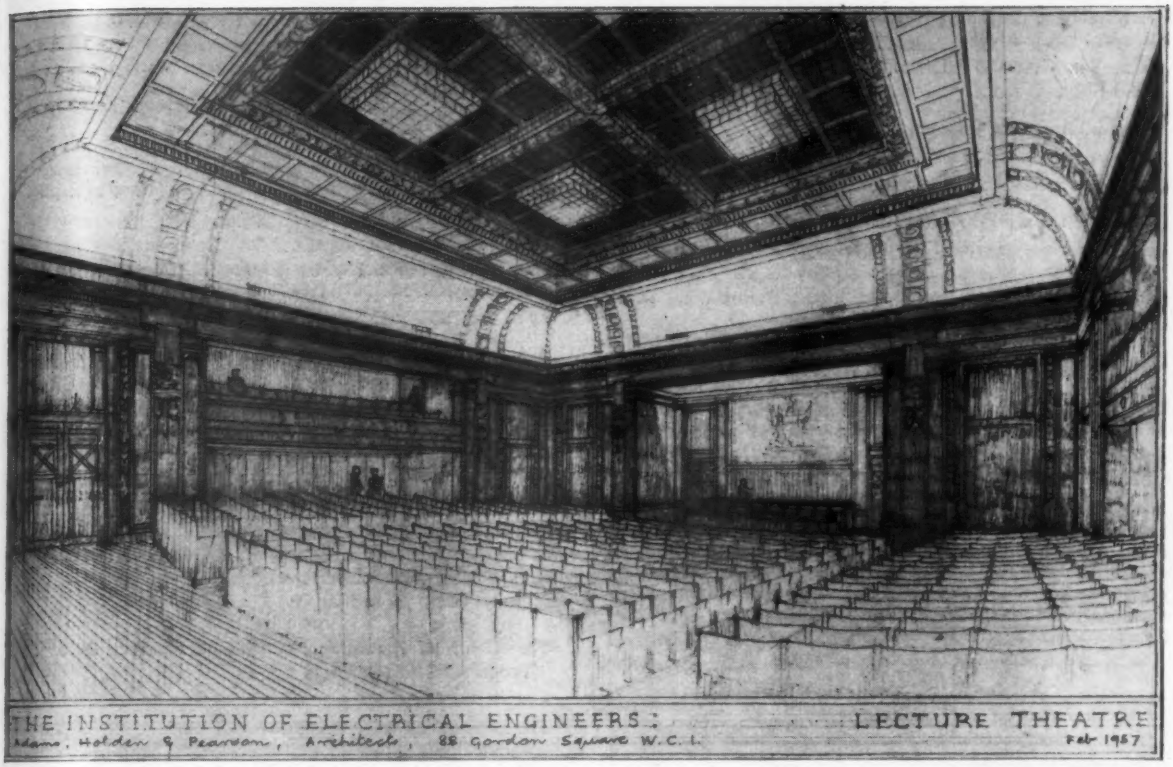
The Proposed Reconstruction of the Institution Building

In the Foreword to last month's issue of the *Journal* it was indicated that the Council had been actively considering the growing inadequacy of the headquarters building, in its present form, for The Institution's requirements, particularly in regard to the Lecture Theatre and the public rooms. Since the time that the Foreword was written the Council have approved certain proposals for reconstruction of the building, which are the result of extended study by an expert committee and by The Institution's consulting architects, Messrs. Adams, Holden and Pearson. A Special General Meeting of Corporate Members and Associates is to be held on the 27th June to consider the Council's proposals, and a note on the Institution building and the suggested reconstruction was sent out with the notice convening the meeting.

Reproduced on this page and the facing page are two architect's drawings that illustrate part of the new proposals. The drawing on this page shows the external appearance of the building with much of its decoration removed, windows added to the top floor, and a deeper hall. The drawing of the Lecture Theatre shows its increased size, obtained by the addition of side wings with galleries above them and a recessed platform for lecturers; new seating would be provided. Lantern slides of these drawings will be shown at the meeting on the 27th June.



THE INSTITUTION OF ELECTRICAL ENGINEERS : RECONSTRUCTION
Adams, Holden & Pearson, architects, 28 Gordon Square W.C.1. Feb 1957


THE INSTITUTION OF ELECTRICAL ENGINEERS :
LECTURE THEATRE
Adams, Holden & Pearson, Architects, 28 Gordon Square W.C.1.
Feb 1957

**Denotes that the publication is also in the Lending Library. The publications cannot be bought through The Institution; the publishers and the prices are given only for the convenience of members.*

BOOKS

SCROGGIE, M. E. 621.396

Foundations of Wireless. 6th ed.*

London, Iliffe, 1957. pp. 349. 22 × 14 cm. 12s. 6d.

This well-known work was rewritten for the previous (1951) edition, and the present edition contains only minor modifications, except that a chapter has been added on semi-conductors.

STEWARD, W. E. 621.315.3

Modern Wiring Practice. 3rd ed.*

London, Newnes, 1957. pp. viii, 228. 23 × 16 cm. 25s.

A practical guide to approved methods of wiring domestic and industrial premises. This edition is in line with the 13th Edition of The Institution's 'Regulations for the Electrical Equipment of Buildings'.

TAYLOR, E. O. (Editor) 621.398

Power System Communications*

London, Newnes, 1957. pp. vii, 304. 22 × 14 cm. 35s.

Deals with power-system control and telemetering over Post Office circuits and carrier circuits on power lines. The apparatus used for the communication circuits is described as well as the arrangements for supervisory control, telemetering, and inter-tripping.

LIBRARY ACCESSIONS

WHITROW, M. (Editor) 014.043

Index to Theses accepted for Higher Degrees in the Universities of Great Britain and Ireland. Volume III, 1952–53

London, Aslib, 1956. pp. xii, 159. 24 × 15 cm. 21s.

OTHER PUBLICATIONS

B.B.C. ENGINEERING DIVISION

Engineering Training in the B.B.C. by K. R. Sturley

London, B.B.C. Engineering Division. Monograph No. 11, 1957. pp. 24. 28 × 22 cm. 5s.

BRITISH ELECTRICAL AND ALLIED MANUFACTURERS' ASSOCIATION

Forty-Sixth Annual Report. 1956–57

London, B.E.A.M.A., 1957. pp. 79. 27 × 20 cm.

EIDGENOSSISCHE TECHNISCHE HOCHSCHULE IN ZÜRICH (Swiss Federal Institute of Technology)

Erzeugung von Ultraschall mit Ferriten (Production of Ultrasonics with Ferrites) by U. Enz

Zürich, Leeman, E.T.H. Prom. No. 2499, 1955. pp. 53. 24 × 17 cm.

Contributions to the Theory of Electrical Circuits with Non-Linear Elements by J. J. Schäffer

Assen, Van Gorcum, E.T.H. Prom. No. 2614, 1956. pp. 95. 24 × 15 cm.

Microwave Reactance Tables by R. C. Knechtli

Princetown, R.C.A. Laboratories, E.T.H. Prom. No. 2489, 1955. pp. iv, 121. 28 × 21 cm.

INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS

Depreciation and Service Life of Telecommunications Plant by N. V. Knight

London, Institution of Post Office Electrical Engineers, Paper No. 209, 1955. pp. 23. 28 × 22 cm. 2s. 6d.

ORGANISATION FOR EUROPEAN ECONOMIC CO-OPERATION

Scientific Manpower for Applied Research. Shortage of Research Workers. How to Train and Use Them?

O.E.E.C., Paris, 1957. pp. 47. 24 × 15 cm. 4s.

Electricity Rates. Administrative Regulations Concerning the Supply of Electricity. A Report Prepared by a Group of Experts.

O.E.E.C., Paris, 1957. pp. 127. 24 × 15 cm. 7s.

The Electricity Supply Industry in Europe 7th Enquiry Achievements and Forecasts 1954–1961. Trends in Economic Sectors

Paris, O.E.E.C., 1957. pp. 60. 21 × 26 cm. 5s.

MONOGRAPHS AND PAPERS
published individuallv this month

Synopses of monographs and papers published individually before the next issue of the Journal are given below, and, unless otherwise stated, their dates of publication are this month. Reprints of all papers are available about two months after publication in the Proceedings. The prices shown below are post free. When ordering please quote serial number of paper or monograph. Books of 8 vouchers may be obtained from the Secretary, price 10s. each.

	PAPER FOR READING	PAPER FOR PUBLICATION ONLY	MONOGRAPH
More than 10 days before first reading (if published early)	2s. 6d.[1]	—	1s. 3d. (From date of individual publication, including period after republication in the *Proceedings*)
Period of 10 days before first reading	Free[2]	—	
Period between first reading and republication in the *Proceedings*	Free if available[2]	—	
Reprints (after publication in the *Proceedings*)	1s. 3d. (includes discussion)	1s. 3d.	

[1] This charge includes a reprint of paper and discussion.
[2] If a reprint of paper and discussion is also required a remittance of 1s. 3d. should be sent.

MONOGRAPHS

A Variable-Velocity Scanner for Magnetic Deflection of a Scanning Spot *Monograph* 241 R

M. P. BEDDOES, B.SC.

Designed initially for use with a method for television band compression by variable-velocity scanning, the performance limitations of a *magnetic* scanner with negative feedback from a novel source are presented: also, some of the many applications of such a scanner are briefly reviewed.

The justification of the presentation relies mainly on the mathematical analysis: however, measurements of current waveforms confirm that the influence of non-linearities and other factors which have been explicitly ignored in the derivation of this analysis is negligible in practice.

Consideration is given to the practical application of the results, and it is shown that satisfactory operation can easily be obtained for repetitive scanning rates up to 10^4 per second with a maximum displacement error (during a change of velocity) of no more than 0·2%.

The Electrical Breakdown of Gaseous Dielectrics at High Frequencies *Monograph* 242 R

R. R. T. FATEHCHAND, B.SC.(ENG.), PH.D.

The continuous-wave breakdown of air and an air/carbon-tetrachloride mixture in uniform electric fields is examined, at frequencies between 3·5 and 30 Mc/s.

The observations in air indicate that if the pressure is reduced to below atmospheric, the high-frequency breakdown voltage does not fall below the 50 c/s value until the amplitude of positive-ion oscillation has become much smaller than the gap width. This result is explained by a breakdown mechanism which depends both on positive-ion accumulation and on the variation of electron-ionization coefficient with electric field strength. Measurements by an air-stream method of a quantity related to pre-breakdown ionization in the gap appear to be consistent with the suggested breakdown mechanism. The h.f. measurements also exhibit the electron-diffusion type of breakdown.

A description is given of the effect of a small admixture of carbon-tetrachloride vapour. Where electron-diffusion breakdown is normally operative, the h.f. breakdown strength increases by up to 50% when the vapour is present.

The Conductivity of Oxide Cathodes: Part 2. Influence of Ion Movements on Matrix Resistance *Monograph* 243 R

G. H. METSON, M.C., PH.D., M.SC., B.SC.(ENG.)

In the second part of his monograph Dr. Metson continues the study of ion movements in an oxide matrix enclosed between two heated core pieces. Ions are divided into two classes—residual gas ions (probably carbon monoxide) resulting from imperfections of processing technique, and oxygen ions resulting from electrolysis of the oxide matrix. The different influences of the two classes of gas on matrix conductivity are distinguished by characteristic reactions, examined in both d.c. and a.c. fields. The effect of electrolytic oxygen on matrix resistance may be profound, and the action is probably a fundamental aspect of cathode operation.

A Precision Dual Bridge for the Standardization of Admittance at Very High Frequencies *Monograph* 244 R

D. WOODS

The author states the need for a more accurate means of admittance measurement in order that a general improvement can be made in the accuracy of measurement of other electrical quantities at radio frequencies. He describes a precision twin-T dual bridge having a range of admittance measurement associated with coaxial systems between 3 Mc/s and 300 Mc/s. The inaccuracy of measurement does not exceed 0·2% in either component of a complex admittance at a frequency of 200 Mc/s. The calibration of the bridge is based on a range of coaxial susceptance standards whose parameters are calculated from length and time measurements. The dual feature of the bridge enables the true r.f. conductance of its internal standard resistor to be established in terms of these standards; the uncertainty in this determination is not greater than 0·1% for frequencies up to 250 Mc/s.

The author emphasizes importance of the design of coaxial terminations for measuring instruments and standards at these frequencies. A practical design is detailed for a coaxial terminal for precision admittance- and impedance-measuring instruments, and the author mentions a proposed universal coaxial connector system for precision r.f. measuring instruments of all types.

Analysis of Transient Conditions Accompanying Switching Operations in Three-Phase Power Systems *Monograph* 245 S

J. H. BANKS, M.SC.

This monograph describes matrix methods whereby the transient voltages and currents produced during switching operations in 3-phase power systems may be evaluated. The appreciable mutual impedances existing between phases of the various items of plant are taken into account. Operational voltage and impedance matrices are derived which define the transient performance of a typical network when a 3-phase circuit-breaker clears a shunt fault, the individual phases of the circuit-breaker being considered to clear sequentially. The successive constraints imposed upon the network currents are defined by transformation matrices with the use of methods based on the work of Kron.

The author also considers the influence of phase mutual impedances upon the transient overvoltages produced during the isolation of single-phase arcing faults on double-circuit overhead lines.

The Concept of Heterogeneous Surface Impedance and its Application to Cylindrical Cavity Resonators *Monograph* 246 R

A. E. KARBOWIAK, PH.D.

The concept of the *heterogeneous surface impedance*, defined as an impedance sheet whose surface impedance varies from point to point in an arbitrary manner, is introduced. The approach is found to yield useful results in a diverse variety of physical situations.

Physical heterogeneous impedance sheets are extremely common, and typical examples are provided by resonators which are built up of several pieces of metals of various conductivities, or which are imperfectly assembled (for example having small gaps between various parts), imperfectly machined or annealed.

The formulae developed relate the Q-factor and the resonant frequency of a cavity to its dimensions and the Fourier components of the surface impedance function, which in general may be anisotropic. The analysis is kept as general as possible and the formulae developed do not exclude any of the practical cases. The author shows that, in general, one cannot ascribe a unique value of the surface impedance to an unbounded periodic sheet, but if its period is sufficiently small (in comparison with the wavelength) the heterogeneous sheet behaves as if it were homogeneous, of surface impedance equal to the mean value of the surface impedance function.

The Approximate Calculation of the Electric Field between a Rod and a Concentric Ring by means of Toroidal Functions *Monograph* 247 M

G. W. CARTER, M.A., *and* S. C. LOH, B.SC.

The electric field set up when a live conductor in the form of a rod passes through the centre of an earthed ring of circular section is approximately calculated by replacing the rod by an hour-glass-shaped conductor of the same minimum radius. The resulting field is found in terms of toroidal functions, numerical tables of which are given. To find how closely the calculated results approach the true values for a rod and ring, a systematic electrolytic tank study is undertaken, and charts of the differences between theory and experiment are given. It is found that the theoretical attack is successful in predicting the smallest figure to which the voltage gradient on the electrodes can be reduced, but that the values of conductor radii which will enable that figure to be realized are somewhat different in practice from those suggested by the theory.

PAPERS

The Design of the Control Unit of an Electronic Digital Computer *Paper* 2365 M: *Part B*

M. V. WILKES, M.A., PH.D., W. RENWICK, M.A., B.SC., *and* D. J. WHEELER, PH.D.

The function of the control unit of an electronic digital computer is to provide the sequences of pulses which, when applied to the store, arithmetic unit, and other units of the machine, cause the orders of the programme to be executed. The paper discusses a number of related ways in which a systematic and flexible design for a control unit may be achieved. In one group of systems the order code is determined by the arrangement of diodes in a diode matrix, and in another by the appropriate threading of wires through a matrix of ferrite cores. The first part of the paper is concerned with logical design, and the second part with the practical design of a system using a ferrite matrix.

A Flying-Spot Film Scanner for Colour Television *Paper* 2390 R: *Part B*

H. E. HOLMAN, G. C. NEWTON *and* S. F. QUINN

Film moving with uniform velocity is scanned by a series of displaced rasters in such sequence that the system is applicable to 50 c/s or 60 c/s conditions. Three photo-multipliers provide colour analysis of the image, element by element, and directly produce a video signal, so avoiding any necessity for accurate optical registration. A particular equipment is described.

The authors examine choice of *R*, *G*, *B*, co-ordinates, and discuss arrangements to minimize colour flicker, to provide uniform field illumination and to offer the most accurate picture reproduction.

To be published early in July.

Elections and Transfers

The following elections and transfers were approved by the Council during April and May 1957.

ELECTIONS

Associate Members

AUN, Chen Chye, D.ENG., B.SC.
BERRESFORD, Burt Howard
BRADY, Thomas William, B.SC.
BUCKLEY, Capt. Kenneth Robertson, R.N.
CARR, John Denzil, B.SC.(ENG.)
DAVIDSON, Ronald, B.SC.
DEWAR, Peter Charles Richmond
EAST, Terence Albert
FRANCO, Victor David
GARDINER, William Nairn
GRIEVE, George
HOUGHTON, Thomas
KWASNICA, Adam Wawrzyniec Antoni, B.SC.
LAWS, Peter, B.SC.(ENG.)
LENNOX, Edwin Arthur, B.SC.
LLOYD-JONES, Group-Capt. Maurice Glyn, B.SC.
MCGOUGH, Arthur
MCKENZIE, Gabriel Robin, D.E.
MARCHANT, Cmdr. Thomas James Germaine, R.N.
MARTIN, Frederick Henry
MILLER, Norman
MORAN, Thomas Patrick
ROBERTS, Lt. (L) David Owen, B.SC.(ENG.), R.C.N.
SATYANARAYANA, Capt. Varahur Srinivasa
SMITHSON, George Arthur
STIBBÉ, Harry
TRAFFORD, Gilmore Henry
VAUSE, Dennis
WIGLEY, Donald Hugh
YATES, Donald

Associates

BROMLEY, Frederick William
BUNNER, Sqdn.-Ldr. Alfred John
COLE, Derick George
FERRES, Capt. Thomas, T.D.
HAYWOOD, Leslie
LEE, Edwin Charles
MCDONALD, Stuart Warden
PAUL, Jagjit Singh, M.B.E.
TREHARNE, Joseph Richard
WEBSTER, Lorenzo Walter Deyes
WHITE, Cyril Herbert Vincent
WILKINS, Edward Arthur
WILLIAMS, Egbert Cleveland

TRANSFERS

Associate Member to Member

ASCHNER, Fritz Simon, DR.ING., DIPL.ING.
BAGGOTT, Albert Jefferies
BECK, Geoffrey Edward, B.SC.
COOKE-YARBOROUGH, Edmund Harry
COVENTRY, Arthur Frederick, B.SC.
CRAWFORD, Alfred Thomas
CURRER, Capt. Robert Urquhart
DEACON, Edwin Arthur
EVANS, Trevor
FELLS, Aubrey
GROOCOCK, John Henry, B.SC.(ENG.)
HILL, Ernest
HUNT, Stanley Thomas
JOHNSON, Harold Bell, B.SC.
KITCHING, Donald Albert
MCDONALD, George John, B.SC.
MILBURN, Capt. Geoffrey William, B.SC.(ENG.)
MILLER, Albert William
PALFREYMAN, Charles Donovan
PEGRUM, Arthur Magnus, B.SC.(ENG.)
PEREIRA-MENDOZA, Vivian, M.SC.TECH.
RICHARDSON, Lt.-Col. George Osborne, B.SC.
SCLAR, David
SEFTON, Morris Lazarus, B.SC.
SUMNER, John Houghton, M.SC.TECH.
TARR, Richard James Clifford
TAYLOR, Lt.-Col. William Henry, B.SC.(ENG.)
THOMAS, Wilfred Roy
THOMSETT, Hector Stuart
TRUTER, Noel William
VALLANCE, Capt. Derwent Bridson, B.E.
WELLER, Herbert Lewis
WOOLFALL, Richard, I.S.O.

Associate to Associate Member

BOWEN, Major Dennis John
COUSINS, William George

Graduate to Associate Member

ABOU-HUSSEIN, Mahmoud Sabri Mahmoud, B.SC., PH.D.
ADAMS, Edward Michael, B.SC.
ALLEN, Peter Henry Gay, B.SC.(ENG.)
ALVA, John Gillies, M.SC.(ENG.)
ANTOSZEWSKI, Eugeniusz, DIPL.ING.
ASHTON, Harold Cecil
ASHWORTH, Norman
AUSTIN, Desmond Charles
BANE, William Thomas, B.SC.
BEADLE, Anthony Crisp, B.SC.(ENG.)
BEADLE, John Edward
BENNETT, Raymond George, B.SC.
BEWICK, Alan
BIBBY, George Leonard, B.SC.(ENG.)
BIRKS, Frederick Hayes
BIRNSTINGL, David Wildon, B.SC.(ENG.)
BOND, Harold William, B.SC.(ENG.)
BRIDGMAN, Arthur Henry Stuart, B.SC.(ENG.)
BURBRIDGE, Ronald Nicholas George
BURRIDGE, Frederick James
CANT, Leonard, B.SC.(ENG.)
CARLICK, Edward Charles
CLARKE, Russell
CLIFFORD, Alexander Ralston, B.SC.(ENG.)
COLCLOUGH, Alan Seymour, B.SC.(ENG.)
CROMBIE, Alan Alexander Cran, B.SC.(ENG.)
CURTIS, Paul William Henry
CUTTING, Nigel David
DAVIES, Albert Cazel, M.C.
DAWSON, George Lovely Robinson, B.SC.(ENG.)
DELAFORCE, Cyril Harry
DOHERTY, Gerald Adrian, B.SC.
DRURY, Philip
DUFF, Robert Lindsay
ELLIDGE, Norman George
ENGLAND, Glynne, B.SC.(ENG.)
ERSKINE, James Brian, B.SC.
EVANS, Leslie Rhys
EVANS, Reginald David, B.SC.
FARRELL, Joseph Anthony
FAULKNER, Gordon

Graduate to Associate Member (contd.)

FIELDHOUSE, Kenneth
FOULKES, Ronald Mitford, B.SC.
GARDINER, Charles Douglas, B.SC., LL.B.
GARVEN, Robert Muir
GATHERCOLE, Dennis Jack
GILMORE, Andrew Gerald, B.SC.
GOLDING, John Maurice
GORE, John Sidney
GOSLING, Jack
GRICE, Alexander Norman
HADLEY, Herbert Kenyon
HARGREAVES, George Vincent
HARPHAM, George Edward
HATHAWAY, Bernard
HILL, Harry Launce
HILLEN, Cecil Frederick John, B.SC.TECH.
HIRST, George
HOLLAND, Douglas Edward
HOWARD, Sydney
INGE, Peter Albert
JAMES, Bruce William Stodart, B.E.
JEAVONS, Lawrence, B.SC.
JONES, Mervyn Breeze
KING, Ernest Jack
KNOWLES, Raymond Stanley
LEONARD, John Tony
LIDDEMORE, Albert Victor
LOWENBERG, Montague
LUND, Alfred Joseph
MCCORMACK, Edmund Patrick
MCDERMID, Geoffrey Ronald
MCNAUGHTON, Ivor Irving
MCNEILL, Gordon Victor
MADDOCKS, David Ross, B.SC.TECH.
MALONE, James Joseph
MANSFIELD, Reginald Frederick
MATHER, Ronald Samuel, B.SC.
MAUDE, Peter Hugh, B.SC.(ENG.)
MAY, Leonard George
MILLER, John Tennant
MILLS, Kenneth Douglas
MORRIS, John Lewis
NAYLOR, Jack Garfield, B.E.
NEWMAN, Peter Henry
PARKES, Eric Stanley, B.SC.(ENG.)
PERRY, John, B.SC.(ENG.)
PICKTHORN, Percival Weston Grahame
RAULIN, John Peter, B.SC.
REEVES, Harold Stanley Victor, B.SC.(ENG.)
REID, John Wilson Gillespie, B.SC.(ENG.)
RICHARDSON, Edward
ROBSON, Allen
ROESSLER, Dudley Prevost Ruthven, B.SC.(ENG.)
RYALLS, Cyril, B.SC.
SALTER, Norman Alfred
SARGEANT, Derrick Gordon, B.SC.
SEARLE, Walter William Ralph
SENHENN, Derek Alan, B.SC.TECH.
SHAYLOR, Harold Raymond
SKARBEK, Ignacy Romuald
STEED, Sqdn.-Ldr. Frederick Stephen, R.A.F. (RET.)
STEVENS, John Anthony
STROUD, Leslie Eric
TAYLOR, Henry Bastian, B.SC.(ENG.)
TEWSON, Michael Beale, B.SC.
THOMPSON, John Pamley, B.SC.(ENG.)
TRIDGELL, Ronald Hugh
WARD, Instr.-Cmdr. Reginald Edward, R.N.
WARREN, David Kingsley, B.SC.
WESTCOTT, David John
WHITE, Ronald Lionel
WILLARD, Reginald Alfred
WILLIAMS, Ronald Albert
WILSON, John
WILSON, Keith William John
WINTERBOTTOM, John Frank, B.SC.
WOOLLARD, Robert MacDonald
WRIGHT, Vernon John
YOUNG, Capt. Gerald Ian, R.E.M.E.

The following elections and transfers approved by the Council are effective from the 25th April 1957.

ELECTIONS

Graduates

BAILEY, Robert Alexander, B.SC.
BEAKE, James Robert
BEWS, Derek
BRASH, John
CHAUDHURI, Pinaki, B.E.E., M.S.
CLARKE, Henry Howard
CROWTHER, Stuart David Goss, B.SC.(ENG.)
CULLEN, Geoffrey Rye, B.E.
CUNNINGHAM, Michael Stephen, B.E.
DUNN, James Radford, B.SC.
FEAVEARYEAR, John Edgar, B.A.
FRERIS, Leonard Leo, B.SC.(ENG.)
GOKHALE, Yeshwant Shripad, B.SC.
GRINHAM, Ernest James
GUY, Robin William
HACKMAN, Allan Charles
HARPUM, Leonard Alfred, B.A.
HARVEY, Robert Clifford
HODGKINSON, Eric
HOLLAND, Liam Ignatius, B.E.
HONEY, Peter Wilfred, B.A.
HORSLEY-HEATHER, Julian Stephen Bernard
HUME, Lt. Robert, B.SC.(ENG.), R.E.M.E.
JOHNSON, Julian Charles
JONES, Gareth Sinclair, B.A.
KIRTLAND, Jack Philip, B.SC.(ENG.)
LAUDER, Ronald Kelty
LEMCO, Ian, B.SC.
LUMBY, Graham, B.ENG.
MCGUIGAN, Francis Gerald
MCKENZIE, Alasdair Bell
MACLAUCHLAN, Lt. Andrew, B.SC.(ENG.), R.E.M.E.
MCVEY, Peter James Wailey, B.A.
MADELEY, Bryan
MARLOW, Brian Anthony
MEALIN, Edmund Ernest John
MOORE, Peter Edwin
MOULD, Capt. Charles Marshall, B.SC.(ENG.)
NICHOL, David Ley, B.A.
PAYNE, John Michael, B.SC.(ENG.)
PEACOCK, John Douglas Collins, B.A.
PETER, Stefan Erwin Ernst
PUTWAIN, Derek Laurence
REBURN, David Arthur, B.SC.
RILEY, Geoffrey
SAWYER, Rodney Stanley
SLABBERT, Eldon Stanford, B.SC.(ENG.)
SMALL, Ernest Peter
SMITH, Eric Llewellyn
SMITH, Michael Russell, B.A.
SYMONDS, John Allan
TIERNEY, John Redington, B.SC.
TURNER, Ronald George
VAN NIEKERK, Graham
WILKINSON, Roger Lyndon Cecil, B.E.
WILLIS, Cecil Arthur
WRIGHT, Gordon Thomas, B.SC., PH.D.

Students

ABEYNAYAKE, Henry Weerasinghe
ACKUN, Jacob Kobina
AHSAN, Saiyid Mohammad Kazim
ALLGOOD, Arthur Peter
BALDWIN, Richard Timothy
BARKHAM, Ronald Nichol
BARTON, Michael Oliver
BEADLE, Nicholas Mark, M.A.

Students (contd.)

BENTLEY, Robert Michael
BETTS, Peter John
BUTTREY, Michael
CALVERT, Thomas William Gillies
CAMPBELL, Kenneth Scott
CLARIDGE, Geoffrey David
CLARKE, Eric
COOPER, Reginald Thomas
COTTIS, Frederick Stanley
DAVIS, David Colin
DICKSON, John Graeme, B.SC.
DOBIE, Alexander Barbour
DOWNHAM, Kenneth William
DOWNING, Derek Frederick
DRUCE, David Brian
EVANS, David
EVANS, Ellis Ivor
FAULKNER, Anthony John
FISHER, Victor Anthony
FREEMAN, Joseph Brian Alexander
GODDARD, Keith Edward
GREGG, Albert, B.SC.
HALL, John Henry
HART, Anthony William
HART, Derek, B.A.
HEWITT, Roy William Samuel
HILL, Bryan James
HOCKENHULL, Nicholas Charles Headington
HODGKISS, Peter Keith
HOLLAND, Alan Dennis
HOLLAND, Geoffrey Thurston
HOWORTH, Harry
HUGHES, Edward John Stuart
JACKSON, Keith Howard
KALE, Francis Peter
KENNETT, Douglas Bryan
KESTER, Gerald Frederick
KINGSTON, Peter Hael
KYBETT, John Trevor
LANE, David Howard
LLOYD, Robin William
LOWDEN, Jeremy Lawrence
LOWE, Gordon Campbell
LUNT, Kenneth Stanley
MCFARLANE, James Dobbie
MILLARD, Anthony Richard
MILNE, Robin John
MOORE, David William
MUKHERJEE, Pradyot Kumar, B.E.
NADZIM, Mohamed
NDUBUKA, Gabriel Akoma
NUGENT, Brian
OWEN, Arthur Ronald
PACKMAN, John Edwin
PARKIN, Roger Edward
PATEL, Lalitkumar Haribhai
PATTEN, Arthur Robert Adrian
PICKARD, Robert Malcolm
POWELL, Roger James
POWNER, Edwin Thomas
REEVE, John
RICHARDSON, Julian
ROSSITER, Brian

Students (contd.)

SMART, Paul William
SMITH, Gordon Reginald
SMITH, Ronald
STAINES, Nigel
STANLEY, James Frederick
STEVENS, Frank Roy
TAYLOR, John Edward
TEMPLER, Richard Edward
TEN KLEY, Willem Berend
UNDERWOOD, Peter Edward, B.SC.
UWAIFO, Solomon Omorodion
VINNELS, John
WALFORD, Ronald Eric
WARE, Joseph, B.SC.
WEBER-BROWN, Nicholas Ellson
WELLING, Peter Francis
WHEELDON, Anthony
WHITLOW, Colin Hubert
WICKEN, Clifford Stanley

TRANSFERS

Student to Graduate

BAGN, Bjørn, B.SC.TECH.
BANNISTER, Gerald Brian, B.SC.
BARGH, John Keith, M.ENG.
BLYTHE, Richard Wilmot
CHOWDHURI, Pranab
CORBETT, Leslie John
DARUK, Czeslaw, B.SC.(ENG.)
DAVEY, Geoffrey Clive, B.SC.
DAVIES, William Moelwyn, B.SC.
FULLER, Keith Lewis, B.SC.(ENG.)
GILLIES, John McGill
HUMPHREYS, John Henry
INSTON, Herbert Henry, B.SC.
JEFFCOTT, Leslie
LEWIS, James Colin, B.SC.(ENG.)
MACINTYRE, Gilbert Roy
MCMULLAN, Victor Jardine, B.SC.
MADANI, Henri, B.SC.
MANOHAR, Vasant Narayan, B.E., M.SC.(ENG.)
MARSHALL, Cedric Thomas
MASKREY, Joseph Norman
NAOUM, Jalal Said
O'BRIEN, Peter John
OTHMAN, Akram Rashid, B.SC.(ENG.)
QADRI, Syed Nizamuddin, B.SC.(ENG.)
ROBINSON, Brian Peter
SABAH, Nassir Husni, B.SC.
SMITH, Walter Ernest, B.SC.
WALKER, Geoffrey Leonard
WATT, Instr.-Sub.-Lt. John David, R.N.
WILLETT, John Graham
YORSTON, George, B.SC.(ENG.)
YOUNG, Garth Owen, B.SC.(ENG.)

Contents of the Current Issues of the *Proceedings*

DATE OF JOURNAL REVIEW OR SPECIAL ARTICLE

PART A. POWER ENGINEERING (JUNE 1957)

Written discussion on **The Moving-Coal Regulator: a Treatment from First Principles**

E. E. WARD, PH.D., AND N. H. SABAH, M.SC.
June 1957 **Transistor Voltage Regulators for Alternators** (PAPER NO. 2334 S)

W. K. CLOTHIER, B.SC., M.E., AND L. MEDINA, DIPL.ING.
February 1957 **The Absolute Calibration of Voltage Transformers** (PAPER NO. 2213 M, NOVEMBER 1956)

G. F. TAGG, B.SC., PH.D.
February 1957 **The Measurement of Earth-Loop Resistance** (PAPER NO. 2165 M, SEPTEMBER 1956)

A. MORRIS THOMAS, B.SC., AND D. F. OAKESHOTT, B.SC.
February 1957 **Choice of Insulation and Surge Protection of Overhead Transmission Lines of 33 kV and Above** (PAPER NO. 2158 S, AUGUST 1956)

C. A. CAMERON BROWN, B.SC., AND A. W. GRAY
March 1957 **Electricity in Modern Commercial Horticulture** (PAPER NO. 2272 U, JANUARY 1957)

MIRIAM V. GRIFFITH, B.SC.
Special article to be published **Some Aspects of Heat-Pump Operation in Great Britain with particular reference to the Shinfield Installation** (PAPER NO. 2273 U, DECEMBER 1956)

Discussion on **The Measurement of Steam Temperatures in Power Stations** before the North-Western Supply Group

PART B. RADIO AND ELECTRONIC ENGINEERING (MAY 1957)

See *Journal*, May 1957, p. 301.

PART C. MONOGRAPHS (MARCH 1957)

See *Journal*, March 1957, p. 187.

ANNOUNCEMENTS TO MEMBERS

HOMES FUND

SUMMARY OF CONTRIBUTIONS RECEIVED TO 25TH MAY 1957

	No. of Contributors	£	s.	d.
£1 000 and over	6	6 000	0	0
£100 to < £1 000	30	6 586	3	0
£5 to < £100	819	8 754	3	3
£2 to < £5	2 011	5 493	14	8
Under £2	21 805	11 324	2	7
		£38 158	3	6

APPOINTMENTS AND NOMINATIONS

BRITISH STANDARDS INSTITUTION TECHNICAL COMMITTEE:

Conduits and Conduit Fittings for Electrical Purposes (*ELE*/80)

The Council have nominated Mr. E. E. Hutchings, B.SC.(ENG.), MEMBER, to serve as their representative on the above new Committee.

COMMITTEE ON REGULATIONS FOR THE ELECTRICAL EQUIPMENT OF AIRCRAFT

The Council have appointed Mr. C. S. Hudson, A.M., PH.D., B.SC., MEMBER, to serve on the above Committee in place of Mr. J. F. Lewis, B.SC.(ENG.), MEMBER, who has been appointed to serve on the Committee as the representative of the Ministry of Supply.

COMMITTEE ON THE APPLICATION OF ELECTRICITY TO INDUSTRIAL PROCESS HEATING

The Council have appointed Mr. R. H. Barfield, D.SC., MEMBER, to serve on the above Committee in place of Mr. N. R. Bligh, B.SC.(ENG.), MEMBER.

WIRING REGULATIONS COMMITTEE

On the nomination of the Association of Supervising Electrical Engineers, the Council have appointed Mr. W. F. Parker, MEMBER, to serve on the above Committee in place of Mr. E. J. Sutton, MEMBER.

On the nomination of the Cable Makers' Association, the Council have appointed Mr. J. R. Cox, MEMBER, to serve on the above Committee in place of Mr. S. E. Goodall, M.SC.(ENG.), VICE-PRESIDENT, who now serves on the Committee in a personal capacity.

CITY AND GUILDS OF LONDON ADVISORY COMMITTEE ON THE ELECTRO-DEPOSITION OF METALS

The Council have nominated Professor J. W. Cuthbertson, D.SC., ASSOCIATE MEMBER, to serve as their representative on the above Committee in place of Mr. H. K. Cameron, B.SC., PH.D., MEMBER.

CITY AND GUILDS OF LONDON INSTITUTE EXPLORATORY COMMITTEE FOR TECHNICAL AUTHORSHIP

The Council have nominated Mr. G. E. Williams, B.SC.(ENG.), MEMBER, to serve as their representative on the above Committee.

GOVERNING BODY OF CARDIFF COLLEGE OF TECHNOLOGY AND COMMERCE

The Council have nominated Mr. J. Vaughan Harries, MEMBER, to serve as their representative on the above Governing Body.

NORTHERN AREA ENGINEERING ADVISORY SUB-COMMITTEE OF THE REGIONAL COUNCIL FOR FURTHER EDUCATION FOR THE SOUTH-WEST

The Council have nominated Mr. F. B. Allcock, B.SC.TECH., MEMBER, to serve as their representative on the above Committee in place of Mr. R. H. Cobbold, B.A., MEMBER.

RETIRED MEMBERS AND THOSE OF LONG STANDING

Members are reminded of a rule which has been in existence for some years and which enables Corporate Members and Associates who have retired from the profession and are still desirous of retaining their membership of The Institution to do so without payment of further subscriptions. It is left to the members concerned to make application to be brought within the rule. The rule, which does not apply retrospectively, is as follows:

Any Corporate Member or Associate who has reached the age of 60 and has retired from the practice of his profession or business may apply to the Council to waive his future annual subscriptions provided that his membership of The Institution has been continuous for at least 25 years. If he desires to continue to receive the *Journal* he can do so on payment of 10s. per annum. Parts A, B and C of the *Proceedings* will also be available to him at the appropriate subscription rates.

In addition to the foregoing, it should be noted that a further rule provides that as soon as a member of any class has completed 50 years of membership he will not be required to pay any further membership subscriptions, regardless of whether he is still in remunerative employment. This rule operates automatically, and the member on qualifying is notified accordingly. If he desires to receive the *Journal* or the *Proceedings* the arrangement for retired members of 25 years' standing also applies.

EXHIBITION OF TEACHING APPARATUS

The Education Discussion Circle of The Institution is arranging an Exhibition of Experimental Apparatus for Teaching Electrical Engineering, at Northampton Polytechnic, St. John Street, Clerkenwell, E.C.1, on the 28th June 1957. A variety of interesting experiments have been offered for this

exhibition, principally by the staffs of technical colleges, and, in order that as many members as possible may have the opportunity of seeing them, the exhibition will open at 2.30 p.m., and not 5.30 p.m., as stated in the programme for the second half of the session. Refreshments will be served in the refectory of the Polytechnic from 5.30 to 6 p.m., and the exhibition will remain open until 8.30 p.m.

The Education Discussion Circle extends a warm invitation to all members of The Institution who are interested in the subject to attend the exhibition.

WIRING REGULATIONS—INTERPRETATIONS

Since September 1956, abstracts of interpretations of the 13th Edition of the Regulations for the Electrical Equipment of Buildings have been published at approximately quarterly intervals; a further selection might therefore have been expected this month, but no matters of general interest have been raised since March, and therefore no June list will appear. The question of further publication will be reviewed in time for a September issue, should this be required.

AWARD OF JAMES WATT INTERNATIONAL MEDAL

On the 10th May Sir George Nelson, President of The Institution of Mechanical Engineers, presented the James Watt International Medal to Professor Bauersfeld. The Medal was founded to commemorate the bicentenary of the birth of James Watt in 1736, and it is normally awarded bi-annually by The Institution of Mechanical Engineers. There have been twelve previous recipients, and Professor Bauersfeld is the first German to be awarded the Medal. He has, since 1905, been a member of the Zeiss organization, and has to his credit numerous inventions and developments in the field of precision engineering and optics. Over 120 major patents bear his name. One of the most exciting and worth-while of his inventions directly affecting the public is the planetarium, familiar to many visitors to New York and other large cities. It is interesting that the first planetarium in the Commonwealth is now under construction at Madame Tussaud's in London, and may be completed this year.

CITY AND GUILDS INSIGNIA AWARD

With reference to the notice about the Insignia Award in Technology of the City and Guilds of London Institute that appeared on p. 53 of the January issue, another member who has received this distinguished award and whose name has come to our notice is Mr. T. A. Lewis, ASSOCIATE MEMBER.

BULLETIN OF ELECTRICAL ENGINEERING EDUCATION

The *Bulletin of Electrical Engineering Education* had its origin in discussions at the Ministry of Education Engineering Summer School for teachers of engineering held at Sheffield University in 1947; this was followed up by a meeting at the Manchester College of Technology early in 1948, to discuss 'more effective interchange of information on teaching and laboratory practice in Engineering'. Little time was lost, for in July of that same year the *Bulletin of Electrical Engineering Laboratory Practice* was launched, and with its second issue the title was changed to *Bulletin of Electrical Engineering Education*. The organizer and prime mover in this venture was Dr. (now Professor) E. Bradshaw, whose original idea it was, and who has continued as Editor ever since—in recent years with the assistance of Mr. J. Rawcliffe and Cmdr. D. K. McCleery.

Now entering its tenth year of production, the *Bulletin* has enjoyed a wide circulation not only in these islands but as far away as the antipodes. Nevertheless, there are probably people unaware of its existence, or unaware of how to obtain it, who would be interested by it. Furthermore, there may be some who have well-tried methods of instruction in electrical engineering, models, diagrams and so forth, and who might be glad to publish these methods for the edification of others engaged in the teaching art.

The *Bulletin* is published twice yearly, in December and June, and the subscription is a modest half-guinea; needless to say, this does not nearly cover the cost of production. Communications and contributions should be addressed to: The Editor, 'Bulletin of Electrical Engineering Education', College of Science and Technology, Manchester, 1.

I.R.E. PROFESSIONAL GROUP ON NUCLEAR SCIENCE

The Fourth Annual Meeting of the Professional Group on Nuclear Science of The Institute of Radio Engineers will be held in New York from the 31st October to 1st November 1957. The Atomic Industrial Forum and the American Nuclear Society will be holding meetings earlier in the same week. Anyone interested in contributing a paper in the field of nuclear engineering, with emphasis on reactor instrumentation and control should approach, before the 30th June, Mr. W. A. Higinbotham, Brookhaven National Laboratories, Upton, New York.

I.R.E. CANADIAN CONVENTION

TORONTO: OCTOBER 1957

A Convention on communication, electronic engineering and nuclear techniques will be held from the 16th to 18th October 1957 by the Canadian Sections of The Institute of Radio Engineers at Exhibition Park, Toronto. An exhibition of electronic and nucleonic equipment accompanies the Convention, and will be some 25 per cent larger than the corresponding one at the similar Convention held in October 1956. A cordial invitation is extended to oversea visitors. Advance particulars may be obtained from the Convention Manager, I.R.E. Canadian Convention, Exhibition Park, Toronto.

COURSE IN INFORMATION ENGINEERING

UNIVERSITY OF BIRMINGHAM: OCTOBER 1957–OCTOBER 1958

A graduate course in Information Engineering will be held in the Department of Electrical Engineering at the University of Birmingham during the coming academic year. The course is full-time, starting early in October 1957 and lasting twelve months. It is open to honours graduates in electrical engineering who have, preferably, had a year or two of engineering experience outside the University. Graduates who satisfy the examiners for the course will receive the degree of M.Sc. The subjects studied will be five from the following: Communication Systems; Communication and Information Theory; Electronic Computers; Automatic Control Systems; Advanced Network Theory; Radio Propagation and Echo-

Ranging Systems; and Electrical Properties of Materials. The fee for the course is £81. Inquiries about it should be addressed to The Graduate Course Supervisor, Electrical Engineering Department, The University, Edgbaston, Birmingham, 15.

POSTGRADUATE DIPLOMAS

KING'S COLLEGE, UNIVERSITY OF DURHAM

Two courses for postgraduate diplomas in Applied Electronics and Electrical Power Engineering are being conducted at King's College, Newcastle upon Tyne. They are open to graduates of at least three terms' standing of any approved university. A candidate must attend a course of study for not less than three terms, and must pass an examination in all subjects. The Applied Electronics course deals with thermionic emission, automatic control, circuit theory, wave filters, waveguides and waveforms. The Electrical Power Engineering course deals with electrical machines, system operation, network calculations, automatic control, electrical instruments, heat engines, fuel technology and hydro-electric development. Further details may be obtained from the Registrar, King's College, Newcastle upon Tyne, 1.

COURSES IN REACTOR TECHNOLOGY

HARWELL: OCTOBER 1957 AND JANUARY 1958

The next reactor technology courses specially arranged for senior technical executives will be held at the Reactor School of the Atomic Energy Research Establishment, Harwell, from the 21st to 31st October 1957, and from the 6th to 16th January 1958. These will be the first such courses for senior executives open to oversea as well as British students.

The courses are planned to give senior industrialists, with a technical background, a general appreciation of reactor technology. The lectures will cover the physical, metallurgical and engineering problems of the design of power reactors and the chemical problems of fuel and effluent processing. There will also be lectures on the United Kingdom's nuclear power programme and on the organization of the United Kingdom Atomic Energy Authority and its relations with industry. Visits will be made to laboratories and reactors within the Establishment.

The fee for each course is £50 (excluding accommodation). Requests for information about these courses should be addressed to the Reactor School, Atomic Energy Research Establishment, Harwell, Berkshire.

CAREERS FOR GIRLS IN ENGINEERING

The Women's Engineering Society is holding a week-end conference on the 13th and 14th July 1957 at the City of Coventry Training College, on the subject of 'Careers for Girls in Engineering'. In addition to the organized sessions, delegates will have time for informal discussions and the exchange of ideas. There will be three main sessions: technical education, industrial training and employment, and professional achievement, followed by an open forum.

The fees are £2 17s. 6d. for non-resident delegates and £3 17s. 6d. for resident delegates. Further details and application forms may be obtained from The Women's Engineering Society, Conference Headquarters, 26 Victoria Street, London, S.W.1.

ULTRA HIGH FREQUENCY CONFERENCE

PARIS: OCTOBER 1957

Under the auspices of the Société des Radioélectriciens an international conference on 'Ultra High Frequency Circuits and Aerials' will be held in Paris from the 21st to 26th October 1957. Full information may be obtained from Congrès Circuits et Antennes Hyperfréquences, Société des Radioélectriciens, 10 Avenue Pierre-Larousse, Malakoff (Seine), France.

TRAINING GRANTS, 1957

THE PLASTICS INDUSTRY EDUCATION FUND

The trustees of the Plastics Industry Fund invite applications from young men or women engaged in the plastics industry for a limited number of training grants towards the cost of a year's full-time study at an approved course leading to a degree, diploma or other equivalent qualification in science, engineering or industrial design. Candidates will be expected to make their own arrangements for acceptance by a university or college of further education.

The value of the grants in the past has been normally of the order of £100, but smaller sums will be awarded when other resources are available to the candidates, and applicants will be expected to have approached their appropriate local education authority for financial assistance. Applications for renewal of grants for a second year will also be considered.

Deferment from national service for periods of up to six years may be granted to students who are registered at the Plastics Institute offices, provided that they can complete the approved course of study prior to their 26th birthday.

Applications for training grants must be submitted in writing to the Secretary to Council, The Plastics Institute, 6 Mandeville Place, London, W.1, by the 13th July 1957.

TECHNICAL COLLEGE TEACHERS

The Ministry of Education has recently published a report entitled 'The Supply and Training of Teachers for Technical Colleges', prepared by a committee under the chairmanship of Dr. Willis Jackson. The report makes forty-six recommendations for improving the supply and training of technical-college teachers. The Government's five-year plan to double the present number of technologists and technicians will require, within the technical colleges, 7000 more full-time, and 8000 more part-time, teachers by 1960–61.

Among the committee's recommendations is a suggestion that industry must make an even greater contribution to the provision of teachers. It must be willing to accept the transfer to full-time teaching work of experienced staff members it can ill afford to lose, and to be prepared, for some years, to lose more than it may appear to gain. In particular, selected senior staff members of industry, commerce and Government departments should be given part-time teaching appointments carrying a special status and title. Also stressed is the need for local authorities to use to the full their power to grant increments for previous experience, so that the salaries under the Burnham scale would compare favourably with those in industry. Pension rights should also be transferable. The committee further recommend that opportunities should be improved for a periodic return of teachers to industry in order to gain further professional experience.

The report may be obtained from Her Majesty's Stationery Office, price 4s.

LONDON REPORT

The Faraday Lecture

In the early evening of Wednesday, the 13th February 1957, people were queueing on one side of Parliament Square to hear Mr. Duncan Sandys holding forth on thermo-nuclear war; at the same time on the other side, in the Central Hall, Dr. T. E. Allibone was enthralling a much larger audience with peaceful visions of *Nuclear Energy in the Service of Man.*

Applications for tickets for the Lecture came flooding into Savoy Place as soon as the first announcements of it were made, and a week before the Lecture, with 2400 tickets issued for 2200 seats, the list was closed. Such was the interest that up to 5.30 p.m. on the day of the Lecture, the Institution switchboard was continually engaged with inquiries for 'just one ticket'—each caller seemed to think that there was a secret hoard somewhere.

This indeed has been the experience all over the country: Honorary Secretaries of the Centres and Sub-Centres where the Lecture has been given have been inundated with requests for tickets. In all, Dr. Allibone has given the Lecture fifteen times—to an audience of about 30000. Moreover the Lecture was televised by the B.B.C. on the 12th March, thus reaching a far wider audience, which is estimated by the B.B.C. to have totalled about five million.

The London audience, as elsewhere, was composed largely of non-members of The Institution, for whom, of course, the Faraday Lectures are primarily intended. The President, and Lady Radley, together with several of the Past-Presidents and Members of Council and their ladies, were present, to enjoy a lecture less austere and easier to assimilate than the more formal lectures in the Institution Theatre.

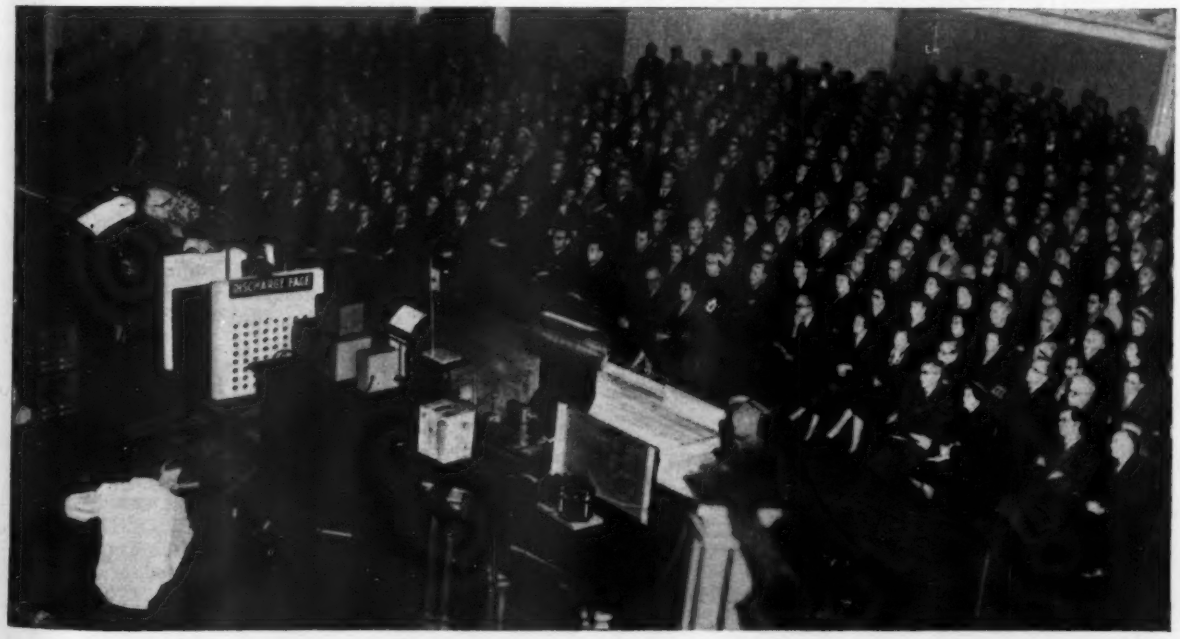
Promptly at 6 p.m. the President preceded Dr. Allibone on to the stage and introduced him to the audience. Then for the next hour and a quarter, with that ease which we who have heard him before know so well, Dr. Allibone held his audience in rapt and undivided attention. Simply, as though it were a personal explanation given to a friend, he described the various ways in which nuclear energy could benefit mankind.

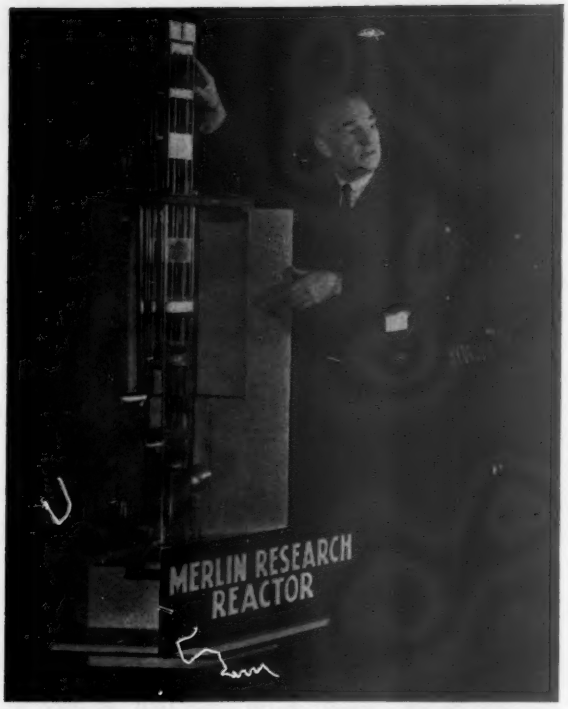
In his introduction the President referred to Dr. Allibone's previous Faraday Lecture *Atoms, Electrons and Engineers* presented during the 1945–46 Session, in which he gave an account of the progress made in applying the then recent discoveries in the field of nuclear fission.

The Lecture Dr. Allibone has been giving this Session may be regarded as Part II of the story, unfolding visions of energy sources and other benefits far beyond the wildest dreams of man. As Dr. Allibone himself put it, 'On the eve of the exhaustion of the known mineral sources of energy, thermo-nuclear reaction offers the vision of energy to spare for as long as the human race endures.'

Dr. Allibone's Lecture fell into four main parts. He first outlined the anatomy of the atom, then explained the principles of reactor design and, beginning with Fermi's reactor, described a number of power reactors, including those of Calder Hall and that of the American submarine *Nautilus.* He then passed on to the hydrogen fusion reaction and

1 *Dr. Allibone seen with some of his demonstration equipment and part of the large audience at the Central Hall*





2 *A demonstration model of Merlin, a research reactor having a uranium core and using water as coolant and moderator*

expressed the view that the difficulties of achieving and controlling thermo-nuclear reaction would be overcome before many years had passed. In this Dr. Allibone held out a message of hope for the future, a vision of power unlimited for the benefit of all mankind. Dr. Allibone explained how the by-products of fission would be used in medical science, in industry and in agriculture to extend our knowledge and in all probability to change the face of agriculture—literally to make two grow where one or even none grew before.

One came away from the Central Hall with the feeling that ahead of us are two turnings. The one leads to the untold miseries of thermo-nuclear war. The other presents the prospect of a world overflowing with untold good. If it is with us to choose, let us go the way pointed by Dr. Allibone.

Sir Gordon Radley voiced the thanks of all to Dr. Allibone for his wonderful Lecture, and the vote of thanks he proposed met with enthusiastic and prolonged applause. This was undoubtedly a Lecture which all who were privileged to hear will remember for years to come. It is hoped to publish, in a future issue of the *Journal*, an article by Dr. Allibone based on his lecture.

ORDINARY MEETING

The Morality of Seeing through People

A paper entitled *A Cyclotron for Medical Research* was read at the ordinary meeting on the 21st March. This was a Measurement and Control Section paper, and its authors were Messrs. J. W. Gallop, D. D. Vonberg, R. J. Post, W. B. Powell, J. Sharp and P. J. Waterton. The paper, which is reviewed on p. 334, dealt specifically with the design and commissioning of the cyclotron now installed in Hammersmith Hospital, but the discussion which followed the presentation of the paper by Mr. Gallop ranged from the medical uses of the machine, through some radiobiology and physics to problems of electrical engineering design, and the points of view expressed created a great deal of interest.

The discussion was opened by Dr. Constance Wood, Director of the Radiotherapy Unit at Hammersmith Hospital. She outlined the uses to which the medical cyclotron would be put, and mentioned in particular the use of the machine in clinical investigations using neutrons as well as X-rays, and its secondary function in producing radioactive isotopes which cannot be made with an atomic pile. Dr. Wood made a charming reference to the contribution made by engineers to her work, and then went on to discuss the historical development of machines for producing X-rays. She amused those present by quoting from a newspaper of about fifty years ago as follows:

> We are sick of the Röntgen rays. It is now said, we hope untruly, that as a consequence of them you can see other people's bones with the naked eye. On the revolting indecency of this there is no need to dwell. Perhaps the best thing would be for all civilized nations to combine to burn all works on Röntgen rays, execute the discoverers and throw the apparatus into the sea. Let the fish contemplate each other's bones if they like, but not us.

Dr. Wood also referred to these same suspicions being expressed in everyday life in all kinds of ways, and read an extract from a London firm of that time advertising 'X-ray proof' clothing with the words:

> Do you want a stranger to see your wife's skeleton? No? Then buy her X-ray proof underwear.

Mr. W. Walkinshaw gave an account of some recent researches at Harwell on the operation of constant-frequency cyclotrons and discussed various methods of producing higher energies by the use of modified equipment. Mr. G. R. Newberry spoke about the performance obtained with the present medical cyclotron and mentioned that at full power the machine would give a computed dose rate of 100 rads/min in tissue at 1 metre. He also mentioned that associated with this fast-neutron dose-rate is a very low gamma dose rate (only a few per cent of the total), and as the biological effect of this will be small it will not be necessary to use special filtration.

Mr. R. Bruce had something to say about the windings for the magnetic circuit. With the emphasis on minimum operating costs, two basic designs of winding were considered, namely paper-insulated copper windings of disc-coil construction cooled by the circulation of transformer oil, and alternatively aluminium windings utilizing an extruded hollow-section conductor arranged for cooling-water circulation within the central hole. Mr. Bruce gave reasons for choosing the latter scheme.

Dr. J. W. Boag made a number of comments on the detailed design of the machine and made some reference to the shielding wall between the cyclotron chamber and the main building, which appears to be known at Hammersmith as 'Boag's folly', apparently because of the very stringent specification laid down for the shielding.

The authors replied to the discussion at some length, and a vote of thanks was proposed to them by Dr. Denis Taylor and carried with acclamation. Finally, the Chairman, Mr. T. E. Goldup, thanked Dr. Constance Wood for opening the discussion and for the tribute she had paid to the work of electrical engineers in the medical field. D. T.

MEASUREMENT AND CONTROL SECTION

Fourier and Filters

For quite a number of members the discussion on *The Analysis of Waveforms* before the Measurement and Control Section, on the 26th February, started over a cup of tea and finished over a glass of beer, the final time limit being imposed by immutably fixed events such as the departure of the 9.30 for Birmingham. The room was pretty full when the Chairman, Dr. Denis Taylor, introduced the opening speakers, Mr. A. Cooper and Mr. D. A. Drew. Mr. Cooper, after stating the types of waveform likely to be met, considered the filter problem in the separation of components, and came down heavily on the side of tuned filters of constant percentage bandwidth, as distinct from the fixed-frequency constant-bandwidth heterodyne type. With one exception other speakers all supported his view. He described the characteristics of his chosen instrument in some detail and pointed to its limitations—limitations mainly on speed of analysis and accuracy of frequency determination.

Mr. Drew's interests lay in vibrations in engines (Fig. 1), and one thing that came out strongly in his remarks, and in those of many other speakers too, was that the problems were often dominated by an acute economic factor. They were working on very big or very expensive jobs, or both, and the time factor in getting results was often economically important. 'Aero engines', said Mr. Drew, 'may cost £100 an hour to run on a test bed or £500 in flight'. Mr. F. E. Butcher stressed the importance of getting results quickly and checking them before an engine was dismantled from the test bed—a process you could hold up for only a limited time. One gathered that, in these cases, time occupied by measurement could be estimated in real money, and a saving by improved techniques might even appear in the accounts.

But, to return to Mr. Drew. The methods used by him and his team, he felt, were amateurish by transatlantic standards. They could provide only three of the forty-eight recording channels sometimes asked for, but the recording 'blind' of a large amount of data very frequently lead to inefficiency, and he favoured a system where, so far as possible, those running the test could be aware of what they were measuring whilst the test was in progress. High-temperature strain gauges tend literally to fall off above 600° C and the wiring at the hot end of an engine is notoriously unreliable, so that it is nice to know whether there is a signal to record. In the case of flight testing, however, especially in small aircraft and, of course, in guided missiles, there is often no alternative to recording a very large amount of data without reference to that which has already been obtained.

In the investigation of the conditions responsible for the resonant excitation of rotating parts, it is often undesirable to linger too long at an engine condition known to be responsible for maximum stress. Measurements are, therefore, often taken during an acceleration, knowing quite well that if the resonance is sharp the stress will not have time to build up to a maximum. Arising out of this is a requirement for a device that would allow engine speeds to be changed rapidly through resonant peaks and yet give a measure of the frequency and amplitude which the signal would have reached if the acceleration had been carried out more slowly. 'The fact', said Mr. Drew, in concluding his remarks, 'that this may be regarded by instrument designers and mathematicians

By courtesy of Armstrong Siddeley Motors Ltd.

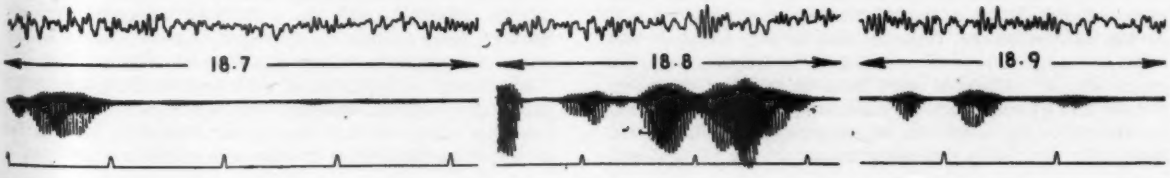
1 *Tuned-filter wave analyser in operation on jet-engine test bed*

The operators are recording relevant frequencies at certain specific speeds up to a maximum of 14000 r.p.m.

2 *Energy distribution in an electroencephalograph waveform*

a Normal voltage/time trace. b Simultaneous trace obtained with narrow-band tuned-filter analyser in circuit.

The analyser is set successively at 18·7, 18·8 and 18·9 c/s, and only voltage variations at those respective frequencies are recorded. Both traces are interrupted temporarily while the filter is being retuned. It may be noted that the main energy component of the waveform is at 18·8/cs.



as unreasonable is no reason why the requirement should not be stated.'

Most of the speakers in the general discussion were concerned with vibration studies. Mr. W. Lake, whose particular interest was marine Diesel engines, put in a plea for a transistorized device capable of converting a signal to digital information, which could be fed to a digital computer, programmed to perform a Fourier analysis. Mr. Butcher described an automatic analyser he had built from standard component instruments, which had brought a long day's manual analysis down to a quarter of an hour's work. His field lay in automobile engines and automobile components. Mr. L. R. Chaplin felt that the time of analysis with a tuned-filter type of analyser was too long. The requirement was for multitrack tapes and multichannel analysers. Mr. K. F. Raby spoke of analysis problems on the output waveforms of alternators, where the most significant harmonics were less than 0·1% of the amplitude of the fundamental. Higher harmonics of quite low amplitude had a special significance because of interference with telephone circuits. He thought the tuned-filter analyser was most suitable, although excellent results had been obtained using a parallel 'T' filter followed by a heterodyne analyser. Mr. C. M. Brownsea laid down the requirements for measurements on power circuits and plant and mentioned the use of third-octave filters.

Dr. S. L. Sherwood spoke of his experience with a tuned-filter analyser in the study of physiological waveforms, and showed electroencephalograph records obtained with the signal from the patient fed through the analyser to the recorder (Fig. 2). He thought that frequency distributions might be correlated with different forms of mental illness.

In thanking the opening speakers and closing the proceedings, the Chairman said that he felt that the meeting had fulfilled all the requirements of an interesting measurement discussion, having provided a good insight into the technology of the field, a great deal of common sense and quite a lot of commercial information. W. C. L.

On Catching your Drift

The discussion on the 26th March 1957 on *The Performance of D.C. Amplifiers with special reference to the Use of Transistors*, opened by Mr. K. Kandiah and Dr. G. B. B. Chaplin, which was originally scheduled to be held in the small and intimate tea room, proved to be so popular that it had to be transferred at the last moment to the more spacious, if also more formal, lecture theatre. Even then there was very nearly a full house, since not only was the subject topical, but the openers were both recognized authorities whose views were eagerly sought. Mr. Kandiah opened the discussion with an admirably delivered nostalgic review of the state of the art as we know it, describing the various devices available, their respective fields of application and their limitations. (Alas, they all have their limitations!) Mr. Kandiah properly observed that, although directly coupled valve amplifiers offer the simplest solution, they are often the least satisfactory, and that any advances which had been made in the past fifteen years were not due to overcoming the fundamental causes of drift in valves but of circumventing them by such devices as modulators. However just as Mr. Kandiah had lulled us into the mood of reverting to fundamentals and the simple life with visions of better-behaved drift-free valves, up popped Dr. Chaplin with the disturbing suggestion of using transistors for d.c. amplifiers. Many present must have come along with the notion that while transistors are all very well for flip-flops and hearing aids, they are hardly the things to use in d.c. amplifiers. Even Dr. Chaplin himself, who is all for knocking the bottom out of the valve market, was obliged to admit that there were difficulties in this connection. He is nevertheless a doughty champion of his pet device and has evidently felt it incumbent on him to coax it into a befitting sense of its responsibilities. One must take off one's hat to both his ingenuity and his assiduity. But even as Mr. Kandiah yearned for low-drift valves, so Dr. Chaplin finally looked to the silicon transistor for salvation. As neither component is yet commercially available we must, in the meantime, keep our fingers crossed.

The discussion which followed was completely informal, and, although there were no fireworks, an ample opportunity was afforded to those concerned either to seek elucidation of some of the points raised, or else to relate their own experiences. After Mr. Kandiah and Dr. Chaplin had answered the various speakers, who numbered about fifteen, Dr. Denis Taylor, who was in the chair, gave a very good summary of the main points which had emerged during the proceedings and proposed a hearty vote of thanks to the openers which was carried with acclamation. J. K. W.

MEASUREMENT AND CONTROL SECTION

SUPPLY SECTION

Problems of Poisoning

The meeting on the 12th March was a joint meeting of the Measurement and Control Section and the Supply Section. It was also a meeting held under the auspices of the British Nuclear Energy Conference, and to add to the occasion, it was, as was pointed out by the Chairman, Dr. Denis Taylor, the 300th meeting of the Measurement and Control Section since its formation in 1928.

After G. J. R. MacLusky had introduced his two papers (a short review of which appears on p. 335) on the use of analogue computers in reactor design studies and in the operation of reactors (by computing xenon-poisoning effects), there followed a lengthy and vigorous discussion. One member, commenting more in anger than sorrow about an omission in one of the figures in the papers, appeared to be proposing a novel type of intellectual effect, since he related a distance travelled by train to the time required to find resistor R19!

In opening the discussion Mr. R. W. Sutton emphasized that the use of analogue computers for the solution of reactor problems involved the reduction of a complex physical system with many non-linear differential equations to a simpler model suitable for analogue solution. He pointed out the care which must be exercised in such reductions of the problem to achieve the most economical analogue. Mr. I. Wilson, continuing the discussion, described two earlier reactor analogue computers which had been built at Harwell, including a novel method of simulating time delays (such as occur with a fluid flowing in a pipe) by means of charges stored on a rotating capacitor drum. He also described a reactor simulator built as a training equipment for the Harwell Reactor School, and gave further details of the linear-to-logarithmic voltage converter which it employs.

In the first of a number of contributions from the foreign guests attending the meeting, Mr. Nils Rydell described the analogue computer built for reactor studies in Sweden. He discussed particularly a simple unit amplifier employing a

directly-heated sub-miniature electrometer pentode as the first valve, and he mentioned that drift rates of less than one millivolt per hour could be obtained without vibrator stabilization. Mr. Rydell went on to call attention to the spurious transients which may occur due to the finite steps in the winding on a servo potentiometer used as a multiplier, and he questioned the utility of the methods proposed by Mr. MacLusky for compensating the servo-multiplier frequency response.

Mr. R. J. Smith confirmed Mr. Rydell's view regarding reactivity potentiometer resolution, particularly when studying the long-term stability of an automatic control system. He described an ingenious 'inversion' of the reactivity servo operation, designed to avoid this difficulty, in which the potentiometer slider is positioned according to the reactor power and the reactivity input is applied across the potentiometer. He went on to describe details of the computer used by the atomic energy group of a large industrial organization, and in this connection disagreed with Mr. Sutton's earlier suggestion on the number of unit amplifiers required. He stated that the eighty amplifiers used in their equipment had been found to be necessary.

The same point was taken up by M. J. Weill of the French Atomic Energy Commission, who described their installation of four analogue computers, each employing up to thirty unit amplifiers. He explained how these could be used individually or interconnected and used together.

A xenon-poisoning computer which avoided large time-constants by operating on an accelerated time scale was described by M. P. Braffort also of the French Atomic Energy Commission. When used in conjunction with an operating reactor, the history of past reactor operating power is stored on a capacitor-drum type of memory, and can then read out at 3 600 times the speed into the input system of the computer. M. Braffort also discussed the most economical methods of reducing reactor problems so that analogue methods could be used. M. Braffort's colleague, M. C. Caillet, followed with a discussion of the use of analogue methods to the solution of homogeneous-reactor design problems, and gave some results of start-up investigations he had made on such reactor systems.

Other speakers emphasized the importance of continually re-examining the validity of the analogue methods which they used, and there was some discussion about the use of transistors in computers of this type.

In conclusion, Mr. R. J. Ryle, the Chairman of the Supply Section, congratulated the author on his paper and thanked the speakers for their contributions to the discussion. Finally a hearty vote of thanks was accorded to Mr. MacLusky. D. T.

RADIO AND TELECOMMUNICATION SECTION

Microscopy—X-Ray and Electron

At the meeting on the 20th March, members of the Section were taken towards one of the present frontiers of science. The subject under consideration was *Recent Developments in X-Ray and Electron Microscopy*. The discussion was an attempt to bring to the notice of the audience recent developments in ways and means of looking at small objects, which are likely to have increasingly important applications in the field of radio and electronics.

To cover two different aspects of the problem there were two speakers. Dr. W. C. Nixon, of the Cavendish Laboratory, Cambridge, spoke briefly of the service provided there with a conventional electron microscope of high resolution (down to about 10^{-7} cm), and went on to discuss two forms of X-ray microscope. The first is a point-source X-ray microscope in which a very small spot of fast electrons falling on a suitable target produces an enlarged X-ray shadowgraph of the specimen under observation. Illustrations of the effectiveness of the technique ranged from fruit-flies to the ball-points of pens. He then explained how an alternative technique, in which the electron spot fell on the specimen itself, can give information about the nature of the material of the specimen. As different sorts of atoms give characteristic X-rays, the analysis of the X-rays produced can determine the location of different sorts of atoms. By using a scanning technique, pictures can be taken, showing up different atoms, as if they were of different colour.

Mr. C. W. Oatley then took up the description of a scanning electron microscope, intended for looking up opaque specimens. Tracing the history of this type of microscope from the original work of von Ardenne, he showed how the introduction of more modern techniques had made possible the type of microscope now operating successfully at the Engineering Laboratory, Cambridge. The microscope has an ultimate resolution approaching 10^{-6} cm and at the same time gives a working distance and depth of focus much in excess of the optical microscope. The exploitation of these advantages was illustrated by photographs of the process of 'forming' a point-contact germanium rectifier. In radio and electronic problems use is sometimes made of the actual electrical properties of the specimen to form the picture. Thus, if a phosphor is put under the microscope, a picture can be formed from the light produced by the phosphor instead of by the secondary electrons normally used in the scanning microscope. One observation made in this way showed that certain phosphor crystals produced all the light from a central spot. Perhaps the use of a suitable automaton to select the good crystals under the microscope could result in brighter television! A final slide showed how the application of a voltage across a *p-n* junction in germanium could result in the display under the microscope of a clear dividing line between *p*- and *n*-type material.

Discussion ranged over a number of topics. The problem of focusing X-rays is apparently solved by the use of mirrors. Answers to questions on the limits of magnification showed that for this one used the field emission microscope, in which certain observed effects were ascribed to individual molecules. After it had been decided that for the present purpose X-rays were waves, not particles, the Chairman closed the meeting with our thanks to the speakers. J. G. Y.

SUPPLY AND UTILIZATION SECTIONS

The two papers read at the meeting on the 14th March were intimately associated with the present developments of railway electrification in this country, and, in consequence, they attracted a large audience which practically filled the lecture theatre. Since the subject matter was of considerable interest also to members of the Supply Section, the meeting was a joint one with that Section.

The first paper was entitled *Electrical Equipment for Rectifier Locomotives* by H. B. Calverley, E. A. K. Jarvis, and E. Williams. This paper dealt with the various types of power circuit which could be used, including h.v. and l.v.

control, on-load tap-changing, buck-boost control, stepless control, bridge and bi-phase rectifier circuits and methods of connecting motors. The different types of tap-changer, transformer and rectifier were also discussed, and the effects of ripple current in the motor circuits were considered.

The second paper, on *Circuit Calculations for Rectifier Locomotives and Motor-Coaches* by T. E. Calverley and D. G. Taylor, drew attention to the limitations of accepted rectifier theory when calculating the performance of bi-phase and single-phase bridge-connected rectifier circuits, and the authors pointed out the inaccuracies in the results of such calculations. A new approach was described to the solution of both transient and steady-state rectifier problems, in which a digital electronic computer was employed, and the results of these calculations were shown to be supported by tests carried out on the Lancaster–Morecambe–Heysham section of British Railways. Short reviews of both papers appear on pp. 337 and 339.

The discussion was opened by Mr. E. L. E. Wheatcroft, who suggested that the so-called simple-infinite-inductance theory did not seem to have any merits, except for those people who were limited to sixth-form mathematics. Dr. J. C. Read expressed the view that the semi-conductor rectifier was worth while, because it would operate immediately on a cold morning without heating up. Mr. S. B. Warder, who is with British Railways, made reference to the tributes which had been paid in the papers to the co-operation and foresight displayed by that body, and observed that to receive compliments of this nature, instead of the usual adverse criticism, was indeed a unique and welcome experience.

It was also pointed out that the railway traction engineer was not a free agent, in that he had to contend with the often severe restrictions imposed by such things as axle loading, loading gauges and arbitrary operating requirements.

The vote of thanks was proposed by Mr. D. P. Sayers, Vice-Chairman of the Supply Section. R. H. R.

NEWS *from the Centres*

MANCHESTER

NORTH-WESTERN CENTRE
RADIO AND TELECOMMUNICATION GROUP

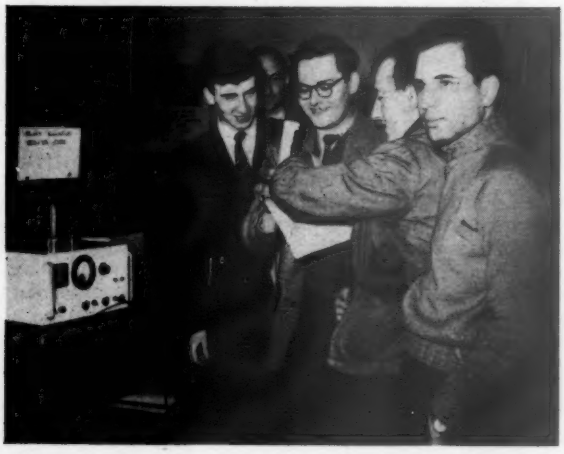
Lemon Power

An exhibition entitled *Electronics at Work* was held by the Radio and Telecommunication Group of the North-Western Centre, in the Electronics Laboratories of the College of Science and Technology, Manchester, on the 26th and 27th March. It was primarily intended to interest young people in the electrical engineering profession. Working equipment demonstrated the kind of apparatus used by those choosing electronic engineering as a career, and also illustrated the way in which electronic devices can be used to solve the problems of research and industry.

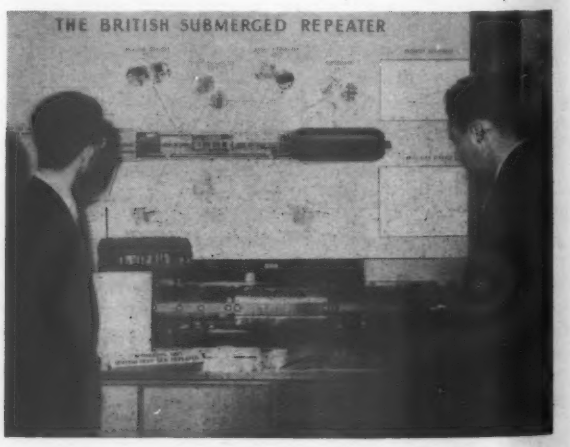
There were seventy-six exhibits, of which the majority were working demonstrations, and many were arranged so that the visitors could operate them. Among them were several television-type displays, including a demonstration of closed-circuit television. A wide range of examples illustrating the use of stroboscopes were available, a number of types of linear induction motor were shown, and a freely floating ball was demonstrated. The versatility and miniaturization which can be achieved with transistors was amply demonstrated by a number of exhibits. In one a transistor was plugged into a lemon, and obtained its power from the citric acid in the fruit.

A working model of an electronic exchange was on show, which had facilities for the visitors to dial 'TIM' and the weather forecast. In the same room, live B.B.C. and I.T.A. television outside-broadcast equipment was available for inspection. Two computers, a noughts-and-crosses machine and a careers computer, which could be operated by visitors, attracted a great deal of attention. There were several examples of electro-luminescence and stroboscopic displays of oscillating crystals.

1 *Some students measure the radioactivity of a luminous watch face*



2 *The big display arranged by the Post Office Engineering Department*



Education officers of various firms were in attendance at the exhibition to give information and advice to the young visitors and to the careers masters. The exhibition had been widely advertised in the technical Press, and posters were displayed in all public libraries in the district and by engineering firms in the neighbourhood. The total attendance on the two days was approximately two thousand, of whom more than half were school-children from seventy local schools.

STOKE, STAFFORD AND STONE

NORTH STAFFORDSHIRE SUB-CENTRE

Computation for Accountants

At the meeting on the 10th January, held in Hanley, Stoke-on-Trent, the Chairman, Mr. A. T. Chadwick, welcomed local members of the various societies of accountants, who had been invited to hear an introductory address on *Digital Computers*, by Dr. S. H. Hollingdale, and a paper on *Power-System Engineering Problems with reference to the Use of Digital Computers*, by Mr. C. Robinson and Mr. D. H. Tompsett.

Dr. Hollingdale briefly sketched the history of digital computers and then explained in some detail the fundamental terminology relating to such computers and the principles of programming. Mr. Robinson and Mr. Tompsett dealt with the application of computers to the solution of problems arising in electricity supply.

Mr. H. A. P. Caddell, opening the discussion, referred to the valuable assistance which computers offered for dealing with the lengthy calculations involved in load-curve analysis, and Mr. H. McCartney proposed a vote of thanks to the three speakers for a very lucid introduction to a subject which was quite new to many of those present.

Chairman's Address

At the Stafford meeting on the 11th February, Mr. A. T. Chadwick introduced and welcomed Mr. C. J. O. Garrard, Chairman of the South Midland Centre. Mr. Garrard spoke of the increasing importance and responsibility of the work of the Sub-Centres with the continued growth of membership, and he indicated that changes in the organization to meet present needs were being considered. He said the Centre Committee were pleased with the vigorous state of the Sub-Centre and wished it every success in its future work.

Mr. Chadwick then presented his Chairman's Address, *Specialization in Training—Instance Transformer Construction*, which had been delayed by his absence abroad during the early part of the session. The address illustrated the breadth of knowledge required to deal effectively with the problems arising in the apparently narrow field of transformer design. Lantern slides were used to show the manufacture of the various constituent materials and the final assembly of power transformers. Mr. H. A. P. Caddell formally thanked the Chairman for his address.

The membership of the Sub-Centre continues to grow at a healthy rate, and it is gratifying to record that a formal welcome as Corporate Members was extended by the Chairman at the January and February meetings to no fewer than nine members.

Annual Dinner

Despite petrol rationing, ninety-eight members and guests attended the Annual Dinner on the 15th February at the Crown Hotel, Stone. The traditional high quality and humour of the speeches again contributed much to the success of the function, while the good attendance provided a credit balance, which, with a small surplus from the dance, enabled a donation of 15 guineas to be made to the Benevolent Fund.

The Lord Lieutenant of Staffordshire, Mr. H. Wallace-Copland, who proposed the toast of The Institution, said we were becoming so used to having electricity that we do not always realize its applications not only in industry but also in travel, medicine, communication and entertainment of all kinds. In reply, Dr. Willis Jackson, Vice-President, said that a larger proportion of young engineers must be attracted to the electrical industry, and this was an individual as well as a collective responsibility. He said that there was nothing better than the education of electrical engineers as a basic training for life.

The toast of the guests was proposed by Mr. H. A. P. Caddell, Vice-Chairman of the Sub-Centre, who, in a witty speech, had a quip for each of the principal guests and extended a warm welcome to all. In responding to the toast, Mr. S. H. Jerrett, Director of the British Pottery Manufacturers Federation, said that electrical engineers carried heavy responsibilities. A proportion of our present troubles might be ascribed to the excellent communication systems, which enable one to know what is going on all over the world while so little can be done about it. If human nature cannot advance at the rate at which science and its applications are advancing, will we go back quicker than we came forward?

L. G.

The scene at the Annual Dinner of the North Staffordshire Sub-Centre

Standing at the back, from left to right: Messrs. D. H. Tompsett, A. Davies, A. P. Baines, R. W. Palmer, J. H. Cansdale, A. R. Blandford, H. A. P. Caddell, H. Wallace-Copland and A. T. Chadwick, Dr. Willis Jackson, Messrs. S. H. Jerrett, C. J. O. Garrard, J. M. Ferguson and E. H. Cox and Dr. E. R. Patrick.
The dancing figures in the background are, unfortunately, only part of the decoration.

By courtesy of Staffs. Photo Service

NEWS *from Abroad*

BRISBANE

QUEENSLAND OVERSEA COMMITTEE

An invitation was received from The Institution of Engineers (Australia) to attend a lecture in Brisbane by Professor S. A. Prentice on the 22nd February 1957. Professor Prentice took for his subject *Oversea Electrical Engineering Training and Industrial Developments, 1956* and explained that his talk was based on inquiries made during a period of eight months' study leave in Europe and North America. He described his objectives as:

1. A study of the organization and teaching programmes of university departments of electrical engineering, including a review of graduate training schemes in industry.
2. An investigation of the current practices and research work in some aspects of high-voltage engineering.

Professor Prentice examined engineering courses in Britain and the United States and thought that in both places there is a process of continuous review. He felt that oversea courses tended to contain fewer subjects and to be more specialized than those in Australia. He regarded as an important development the introduction in the United Kingdom of courses leading to the award of the new Diplomas in Technology.

Comment was made on the financing of universities, both here and abroad, and on the benefits of the longer-term budgeting adopted in Britain and America. It was noted that benefactions and response to appeals were markedly better in Britain than here. In Britain, industry gives good support, while in America the interest of the alumni in their university is a striking feature.

It is intended that the design of the new Engineering School at the University of Queensland, St. Lucia, will incorporate many features studied oversea, and it is hoped that local industry will give adequate support.

Professor Prentice spoke very highly of the broadening effect of the conferences that take place in Europe and of the need for persistent reading and correspondence to keep abreast of development. He was particularly impressed with the C.I.G.R.É. and I.E.C. conferences, but regarded as one of the highlights of the trip the British Thomson-Houston Summer School. These schools are held at four-yearly intervals to enable heads of electrical engineering departments of British Commonwealth universities to make close contact with a manufacturing industry and to take part in a series of discussions on new developments.

Professor Prentice spoke very highly of the hospitality offered to visitors but regretted that language limitation prevented a full appreciation of Continental development owing to the difficulty of getting to know representatives from foreign countries and of following their lines of thought. At conferences, a highly efficient translation service made it possible to follow papers and discussions, but this could not provide the true personal contact that would come through informal discussion and conversation.

Industrial development observed during visits had been referred to at the C.I.G.R.É. conference. Of particular significance was the use of computers in industry and the application of the computer on an experimental basis to transformer design. The use of epoxy resin in switchgear and current transformers was giving good results and reducing costs. High-voltage research was studied by Professor Prentice, and he noted that the high-voltage problems of power engineering were being left to the large companies.

The lecture was extremely well attended, there being practically a capacity audience. After some general discussion, a vote of thanks proposed by Mr. J. E. Morwood was carried with acclamation. W. I. G.

BUENOS AIRES

ARGENTINA JOINT OVERSEA GROUP

A meeting of the Argentina Joint Oversea Group was held at the English Club, Buenos Aires, on the 11th April 1957, when our guest speaker was Professor S. Devons of Manchester University. Professor Devons gave us a most interesting talk on the subject of the 250 ft-aperture radio telescope at Jodrell Bank, Cheshire. About thirty members and guests attended the meeting, and Professor Devons afterwards answered questions from those present.

Follett Holt Fund

The Committee of the Argentina Joint Oversea Group has called the attention of members of the Group to the existence of the Follett Holt Fund, the interest from which is devoted exclusively to provide premiums for papers presented before the Group. It is several years now since a premium has been awarded, and the Committee encourage members to present papers that might be considered for this award. A. C. T.

OVERSEA ATTENDANCE REGISTER

During the period 1st April to 30th April 1957 the following members called at the Institution building and signed the Attendance Register of Oversea Members:

CARRUTHERS, P. O., B.E. (Bombay)
CHAPMAN, W. J. (Kenya)
FINCH, K. W., B.SC.(ENG.) (Port of Spain, Trinidad)
FROST, A. C. H., B.SC.(ENG.) (Sydney)
GUY, F. (Rio de Janeiro)
HARPER, R. F. (Kano, Nigeria)
HORT, E. P. (Kirkuk, Iraq)
HUNTER, G. L., B.SC. (Luanshya, N. Rhodesia)
LANGFORD, R. C., B.SC.(ENG.), PH.D. (Newark, U.S.A.)
LEONG, K. O. (Kuala Lumpur)
MARTINDALE, Lt.-Col. J. P. A., B.A., B.SC. (Ringwood, Melbourne, Australia)
PATEL, R. R. (Calcutta)
PAYNE, C. C. (Perth, Western Australia)
RIDLER, P. F., B.E. (Khartoum)
SMITH, D. (Kuala Lumpur)
SUMNER, J. H., M.SC.TECH. (Kuala Lumpur)
WOOLFALL, R., I.S.O. (Nairobi)
VAHI, P. L., B.SC. (Bombay)

Forthcoming Events

June 1957

28 *Friday* Exhibition of Apparatus for Teaching Electrical Engineering (At Northampton Polytechnic, St. John Street, E.C.1, 2.30–8.30 p.m. Refreshments, 5.30–6)

July 1957

1–5 *Monday–Friday* Summer Meeting in the North-Western Centre

September 1957

5–9 *Thursday–Monday* Supply Section Visit to Belgium

18–22 *Wednesday–Sunday* Radio and Telecommunication Section Visit to the Netherlands